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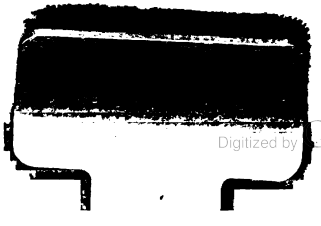
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SUPPLY AND CONSERVATION OF NATURAL GAS IN THE STATE OF PENNSYLVANIA

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Proceedings Before . . .

THE PUBLIC SERVICE COMMISSION OF THE COMMONWEALTH OF PENNSYLVANIA

AT

PITTSBURGH, PENNSYLVANIA

JANUARY 8, 1919

HARRISBURG, PA.:
J. L. L. KUHN, PRINTER TO THE COMMONWEALTH
1919

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IN RE,—
SUPPLY AND CONSERVATION OF NATURAL GAS IN THE STATE OF PENNSYLVANIA.

FILE No. C. 2572
1918.

Hearing before Hon. John S. Rilling and Hon. William A. Magee, of the Public Service Commission of the Commonwealth of Pennsylvania, held in Room 811 of the City-County Building, Pittsburgh. Pennsylvania, Wednesday, January 8, 1919, at 10 o'clock A. M.

PRESENT:

Hon. John S. Rilling, Commissioner,
The Public Service Commission, Harrisburg, Pa.

Hon. William A. Magee, Commissioner,
The Public Service Commission, Harrisburg, Pa.

F. Herbert Snow, Chief, Bureau of Engineering,
The Public Service Commission, Harrisburg, Pa.

H. E. Ehlers, Chief, Bureau of Rates and Tariffs;
Assistant Chief, Bureau of Engineering,
The Public Service Commission, Harrisburg, Pa.

C. J. Joyce, Chief, Bureau of Accounts and Statistics,
The Public Service Commission, Harrisburg, Pa.

R. F. Busher, Assistant Chief, Bureau of Accounts and Statistics,
The Public Service Commission, Harrisburg, Pa.

E. V. Babcock, Mayor of the City of Pittsburgh,
Stephen Stone, City Solicitor, and
George N. Monro, Assistant City Solicitor, representing,
The City of Pittsburgh.

John Gates, Esq., Pittsburgh, Penna., representing,
Equitable Gas Company.

S. L. Gilson, Esq., City Solicitor, Erie, Penna., representing,
City of Erie.

A. Leo Weil, General Counsel, and
Malsolm Goldsmith, Esq., Pittsburgh, Penna., representing,
Manufacturers Light & Heat Co.

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D. W. Anderson, Esq., Borough Solicitor, Donora, Penna., representing,
Borough of Donora.

Christy Payne, Esq., Pittsburgh, Penna., and
John B. Tonkin, Vice President, Pittsburgh, Penna., representing
Peoples Natural Gas Company.

T. B. Gregory, Esq., Washington, D. C.,
Chief of the Natural Gas Department of the
United States Fuel Administration.

S. M. Altdoerffer, Manager, Ambridge, Penna., representing,
Ambridge Gas Company.

J. E. Engle, General Manager, Connellsville, Penna., and
F. I. Falk, Secretary, Pittsburgh, Penna., representing,
Fayette County Gas Company.

C. W. Baker, Secretary and Treasurer,
T. I. Hann, General Manager,
J. W. Shay, Vice President, (all of Pittsburgh), representing,
Greensboro Gas Company.

E. E. Batchelor, Auditor, and
W. A. Spronkle, Secretary, of Pittsburgh, Penna., representing,
Natural Gas Company of West Virginia

Harry Bradley, President, Wellsville, New York, representing,
Empire Gas & Fuel Company.

J. G. Burford, Secretary and Treasurer, Pittsburgh, Penna., representing,
Taylorstown Natural Gas Company.

S. O. Cratty, Councilman,
J. H. Smith, Councilman, Pitcairn, representing,
Council of Pitcairn.

Joseph N. Huston, Boro Solicitor, Pitcairn, Penna., and
W. W. Keeley, Pitcairn, Penna., representing,
Boro of Pitcairn.

H. J. Crawford, President, Emlenton, Penna.,
A. C. Fleming, Superintendent, New Bethlehem, and
J. B. Wykoff, Assistant Treasurer, Pittsburgh, representing,
Pennsylvania Fuel Supply Company.

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Raymond Cross, President, Oil City, Penna.
L. L. Graham, Vice President, Oil City, Pa.,
Thomas B. Weymouth, Chief Engineer, Oil City,
C. E. Oliver, Oil City, Penna., representing,
United Natural Gas Company.

L. B. Denning, Vice President, Pittsburgh, Penna., representing,
Fayette County Gas Company.

Dexter Edge, Pittsburgh, Penna., representing,
American Sheet & Tin Plate Co.

J. W. Farner, Port Allegany, Penna., and
E. B. Reeser, Vice President, New York City, representing,
Potter Gas Company.

Hon. J. B. Cessna, Erie, Penna., and
Hon. Miles Kitt, Mayor, Erie, Penna., representing,
City of Erie.

T. B. Foley, President, Pittsburgh, Penna.,
Main & Company, Auditors, Pittsburgh, Penna., representing,
Rock Run Gas Company.

John B. Corrin, Vice President, Pittsburgh, Penna., representing,
Hope Natural Gas Company.

James C. Griffin, Erie, Penna., representing,
Erie Manufacturers' Association.

B. L. Hawkins, Auditor, Buffalo, New York, representing,
Eastern Oil Company.

D. B. Heiner, Esq., Kittanning, Penna.

F. T. Hepburn, Vice President, New York City,
David I. McCahill, Esq., Counsel, Pittsburgh, Penna.,
P. J. Morrissey, General Manager, Johnstown, Penna., representing,
Johnstown Fuel Supply Company.

C. V. Critchfield, Esq., Cleveland, Ohio.

C. M. Heeter, President, Butler, Penna., representing,
Duff City Gas Company.

David O. Holbrook, Pittsburgh, Penna., representing,
Natural Gas Association of America.

William S. Horn, Burgess, Galeton, Penna., representing,
Boro of Galeton.

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Robert Jackson, Esq., Corporation Counsel, Jamestown, N. Y.

Nathan B. Jacobs, Pittsburgh, Penna., representing,
Morris Knowles, Inc.

S. E. Johnson, Burgess, Port Allegany, Penna., representing,
Port Allegany, Penna.

Elisha K. Kane, Esq., President, Kushequa, Penna., representing,
Peoples Gas Company, Mt. Jewett.

Joseph G. Kane.

G. T. Kincaid, Esq., Borough Solicitor, Corry, Penna., representing,
Borough of Corry.

B L. Langworthy, Shinglehouse, Penna.

G W. Larkins, Ford City, Penna.

J. P. McNarney, Solicitor, Emporium, Penna.

Carroll Miller, General Manager, Pittsburgh, Penna., representing,
Philadelphia Company.

M. H. Murray, Pittsburgh, Penna., representing,
N. C. Davison Company.

Louis Nunschke, Councilman, Austin, Penna., representing,
Borough of Austin, Penna.

I. A. Nuss, Boro Secretary, Elkland, Penna., representing,
Boro of Elkland.

J. W. Offutt, Superintendent, Ellwood City, Penna., representing,
National Tube Company.

S. J. Orr, Superintendent, Greenville, Penna., representing,
Mercer County Gas Company.

T. W. Phillips, Jr., President, Butler, Penna., representing,
T. W. Phillips Gas & Oil Co.

L. P. Scott, Counsel, Pittsburgh, Penna., representing,
Manufacturers Light & Heat Co.

H. L. Smith, Auditor, Pittsburgh, Penna., representing,
Carnegie Natural Gas Company.

W. H. South, Manager, Morgantown, West Virginia, representing,
Randal Gas Company.

F. W. Sorne, Manager, Greenville, Penna., representing,
Greenville Natural Gas Company.

E. S. Templeton, President, Greenville, Penna., representing,
Greenville Natural Gas Company.

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Albert L. Thomas, Esq., Meadville, Penna., representing,
City of Meadville.

George Wittmer, Jr., Treasurer, Pittsburgh, Penna., representing,
American Natural Gas Company.

Edw. M. Wheeler, Buffalo, New York, representing,
West Virginia Central Gas Co.

T. C. Wood, Councilman, Elkland, Penna., representing,
Boro of Elkland.

Samuel S. Wyer, Columbus, Ohio, (Gas Expert).

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COMMISSIONER RILLING: We assure you, gentlemen, we are very much gratified at the attendance at this meeting. When this conference was first suggested, we thought that perhaps a dozen of us might gather around the conference table, and in an informal way discuss the matter of the supply and conservation of our natural gas. The suggestion met with such hearty favor and has grown to the proportions you see, for which we are all very thankful. This is to be a meeting for the purpose of informing ourselves on this important subject, and I trust that everybody here will not hesitate at any time, when he feels so inclined, to ask questions of the speakers who are to address us at this time.

What we are after is to find out the facts; we want all the knowledge we can obtain, and we have the parties here, I think who can furnish it to us.

We are favored this morning by having with us Mr. T. B. Gregory, the chief of the Natural Gas Department of the Fuel Administration of Washington, and we will ask Mr. Gregory if he will not please say a few words to us on this occasion. Mr. Gregory.

MR. T. B. GREGORY, Chief of the Natural Gas Department of the Federal Fuel Administration, spoke as follows:

Judge Rilling, Commissioner Magee and Gentlemen:—I did not come prepared to make any remarks, but for a meeting of this kind, which is called principally in regard to the conservation and supply of this important fuel, especially to the State of Pennsylvania and the activities of the Natural Gas Bureau, of which I have the honor to be the Director, even on the line of conservation for the domestic consumer, I think I might refer to some specific instructions, and those you will find in publication No. 28 of the United States Government, which all gas companies were furnished copies of, it being a proclamation by the President of the United States, and rules and regulations governing licensees engaged in the business of importing, manufacturing, distributing and transporting crude oil, fuel oil, gas oil, paraffine, gasoline and natural gas.

On page 6 will be found a classification of the consumers of natural gas, and by referring to Class 1, you will find that the reasonable use of natural gas was granted to the domestic consumer; that Class 2 is for a restricted use for gas engines and for generating electric current for domestic service. Class 3 is another restricted use. Class 4 and Class 5 are for manufacturing purposes principally. Classes 4 and 5, after the signing of the armistice, were consolidated under an order issued December 7, 1918, so that Classes 1, 2 and 3 are those under which the Fuel Administration is functioning principally at this time.

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One or two propositions that have been presented to the Administration have been rather complicated, owing to the failure of the natural gas supply of West Virginia, which we in Pennsylvania are so dependent upon; the communities of this state you might say are all directly or indirectly affected by the supply from that state. Erie is probably as much affected as the City of Cleveland in Ohio, although it is not receiving its supply directly by lines receiving a supply from West Virginia; but nevertheless it is indirectly affected by the supply. The City of Louisville requested, through the city attorney, that the gas supply of Virginia be rationed in the state. At a very extensive hearing, upon a request of this kind, the Fuel Administration took the ground at that time they would not ration the gas in the State of West Virginia, but instead an order was issued, rationing the gas in the City of Louisville to 1,000 feet per day to each domestic consumer, or each domestic meter. A statement was made by which this ration could be increased to 2,500 feet per day, if the city authorities would allow the manufacture of artificial gas to take care of the peak requirements. There is available not to exceed eight million cubic feet per day to the City of Louisville through the lines supplying that city. This will take care of their requirements, ordinarily giving a full supply. The demands during the peak load will exceed 22,000,000 feet per day, an amount that it is impossible to transport through the present lines, even if the supply were available. Increasing the rationing from 1,000 cubic feet per day to 2,500 feet per day would only affect about 1½ per cent. of the consumers, consequently we felt very safe in making the additional allowance, provided the artificial gas was allowed by the city authorities to be manufactured for the peak load requirements.

Another interesting case brought to our attention was the Potter Gas Company case, of Pennsylvania, and New York. It was shown where the supply available to the Potter Gas Company was failing very rapidly. The last winter the citizens of Elmyra for many days were entirely deprived of a natural gas supply. With all this in view, orders were being issued by the State Fuel Administrator of Pennsylvania, compelling that company to supply a glasshouse manufacturing principally beer bottles and whiskey bottles. Certain orders were issued and the State Fuel Adminitsrator would countermand them. It became a very notorious case and it was given considerable publicity through misleading newspaper articles,—principally, though, those articles were appearing in Philadelphia papers. Shortly after my appointment as Director of Natural Gas, the matter was brought to my attention and a hearing was held in the City of Washington, which was attended by various representatives of the Potter Gas Company, and an order was issued, limited the consumers of natural gas in the State of Pennsylvania to 24,000 feet per month.

and those residing in the State of New York to 12,000 feet per month. While we were holding this hearing, an order was presented by the Potter Gas Company, which they had received from the State Federal Administrator of Pennsylvania, instructing them to supply this bottle works with gas, although the hearing developed that even at that time of year, which was in the early fall, to do so would deprive domestic consumers of a supply of natural gas in the City of Corning and the City of Elmyra, New York. I instructed the Potter Gas Company to disregard this order—and as a consequence I have gotten in wrong with the State Fuel Administrator.

To show that the supply of gas is becoming exhausted, within the past few days I have approved a contract made by that company for a supply of gas, in which they are paying 20 cents per thousand in the field, on an eight-ounce pressue, and I might say that the glasshouse which they were receiving orders to supply—the contract that they claimed to hold, called for a price of 10 cents per thousand feet. So it would show that some one was at fault as to whether the contract was too steep, or this last one was too much, if the supply was available. I will leave you to judge.

Another case that was recently brought to our attention was the available supply of natural gas furnished by the Logan Natural Gas & Fuel Company to communities in Ohio and Indiana. This would affect, I suppose, an excess of 200,000 domestic meters. I think I will just read that order for your information:

"UNITED STATES FUEL ADMINISTRATION,

OIL DIVISION.

WASHINGTON, D. C.

December 12, 1918.

The Logan Natural Gas & Fuel Co.,
The Marion Gas Co.,
The Fremont Light, Heat & Power Co.,
The Bellevue Gas Co.,
The Citizens Gas & Electric Co.,
The Newark Natural Gas & Fuel Co.,
The Buckeye Gas Co.,
The Athens Gas-Light & Electric Co.,
Columbus, Ohio.

Gentlemen: It appearing from evidence submitted as a hearing in the Fuel Administration Building, Washington, D. C., December 10, 1918, that the natural gas supply of the Logan Natural Gas & Fuel Co. is inadequate to meet the demands made upon it from consumers in classes 1, 2 and 3, under the classification of consumers as given in the publication No. 28, containing rules and regulations promulgated by the United States Fuel Administration, dated September 24, 1918,

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and amended by the order of the United States Fuel Administration of December 7, 1918, and as this fact was admitted by the said Logan Natural Gas & Fuel Co. and concurred in by the various natural gas companies, represented at this hearing, as well as representatives of communities dependent upon the supply of Logan Natural Gas & Fuel Co., and in view of the fact that the Logan Natural Gas & Fuel Co. has already discontinued service to consumers served directly by it, classified in lower classes, for the duration of the winter, and the Dayton Gas Co. has taken like action, you are directed to immediately discontinue the supply of any gas that may be delivered directly or indirectly to consumers classified in a lower class than class 3 until April 15, 1919, unless otherwise ordered.

A similar order will be sent to the Jantha Light & Fuel Co., Greenville, Ohio, Dayton Gas Co., Dayton, Ohio, Richmond Light, Heat & Power Co., Richmond, Ind., Lynn Gas Co., Lynn, Ind., Interstate Public Service Co., New Castle, Ind., Central Indiana Gas Co., Notlesville and Tipton, Ind., Middletown Gas Co., Middletown, Ind., Selma Gas Co., Selma, Ind., and the McClain Bros., Jeromeville, Ohio. We desire to be advised promptly of your compliance with this order.

Yours very truly,

U. S. FUEL ADMINISTRATION, OIL DIVISION, BUREAU OF NATURAL GAS,

By T. B. GREGORY,
Director."

An interesting situation developed in the City of Alliance, Ohio, and this is shown by a statement that I will read, and I will follow it by an order in regard to that city:

"STATEMENT ACCOMPANYING ORDER OF JANUARY 4, 1919, ESTABLISHING REGULATION TO PROVIDE NATURAL GAS FOR THE CITY OF ALLIANCE, OHIO.

The city of Alliance, Ohio, has for the past ten years received its supply of natural gas from the Alliance Gas and Power Company, which in turn secured its supply from the East Ohio Gas Company. The contract between these two companies expired on October 31, 1918, and the East Ohio Gas Company, in pursuance of a notice which it had given to the Aliance Gas and Power Company more than a year previous thereto, announced its intention of cutting off all future supply of natural gas. Suit was brought by the city of Alliance and the Alliance Gas and Power Company against the East Ohio Gas Company to prevent the cutting off of the supply. The action resulted in a dismissal of the petition.

At the request of the United States Fuel Administration the East Ohio Gas Company has temporarily continued the supply of natural gas until an investigation and hearing could be had. The hearing took place on December 30 and 31, 1918, at the offices of the United States Fuel Administration in the city of Washington, D. C. Representatives of the East Ohio Gas Company, of the Alliance Gas and Power Company and of the City of Alliance were present. The facts were established that the cutting off of the supply of natural gas

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at this time would result in great suffering and hardship to the domestic consumers of Alliance. War conditions have interferred with the necessary steps to secure a sufficient supply of artificial gas, and it will be impossible for a large part of the population to make the necessary changes to use other fuel at this time.

Under these circumstances the United States Fuel Administration has decided to require the East Ohio Gas Company to continue to supply natural gas to the Alliance Gas and Power Company during the coming winter and until November 1, 1919, which will afford a reasonable opportunity to take such action as may be necessary to secure other means of heating and lighting for the city. Proper regard has been given to the interests of other communities supplied by the East Ohio Gas Company by providing that the amount furnished to the Aliance Gas and Power Company shall not exceed its fair proportion of the total quantity of natural gas in the branch of the East Ohio Gas Company system which supplies Alliance with gas. The East Ohio Gas Company receives from its direct consumers a rate of thirty-five cents per thousand cubic feet and it was accordingly thought proper to fix the price to be paid by the Alliance Gas and Power Company at the same figure. The city authorities of Alliance have agreed to authorize the Alliance Gas and Power Company to make a charge to its consumers of fifty-three cents per thousand cubic feet with a discount of three cents per thousand cubic feet for payment within fifteen days after date of bill, and to take such other action as may be necessary to insure an equitable distribution of the quantity of gas furnished to the Alliance Gas and Power Company among the domestic consumers, who under the reguations of the United States Fuel Administration are entitled to a preference in the distribution of natural gas."

And here is the order:

"UNITED STATES FUEL ADMINISTRATION
WASHINGTON, D. C.

January 4, 1919.

ORDER ESTABLISHING REGULATION TO PROVIDE NATURAL GAS FOR THE CITY OF ALLIANCE, OHIO.

IT APPEARING to the United States Fuel Administrator that the East Ohio Gas Company is about to discontinue the supply of natural gas to the Alliance Gas and Power Company and that much hardship and suffering will result to the inhabitants of Alliance, Ohio, unless provision is made for a continuance of the supply of natural gas, and that therefore it is necessary to issue a regulation to insure an equitable distribution of the supply of natural gas to such consumers.

THE UNITED STATES FUEL ADMINISTRATOR, acting under authority of an Executive Order of the President of the United States, dated 23 August, 1917, appointing said Administrator, and of subsequent Executive Orders, and in furtherance of the purpose of said Orders and of the Act of Congress therein referred to and approved August 10, 1917,

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HEREBY MAKES AND ESTABLISHES the following regulation, effective January 6, 1919, and until November 1, 1919, or until further or other order, and subject to general or specific modification hereafter from time to time, and at any time:

REGULATION PROVIDING NATURAL GAS FOR THE CITY OF ALLIANCE, OHIO.

The East Ohio Gas Company is hereby required and directed to deliver to the Alliance Gas and Power Company such quantity of natural gas as may be required by the Alliance Gas and Power Company, not, however, to exceed the proportion of the natural gas passing through the Alliance-Youngstown-Warren branch of its system which the total number of meters served by the Alliance Gas and Power Company bears to the total number of meters served by said branch line, delivery to be made at the city limits of Alliance, Ohio, through a measuring device to be installed at said point by the East Ohio Gas Company. Payment for said natural gas shall be made by the Alliance Gas and Power Company to the East Ohio Gas Company on or before the fifteenth of each succeeding month at the rate of thirty-five cents per thousand cubic feet, measured under an eight-ounce pressure computed according to Doyle's Law, subject to a discount of three per cent. if paid as herein provided.

(Signed) H. A. GARFIELD,
United States Fuel Administrator."

As this meeting was called particularly to take into consideration the conservation of natural gas, an order will be given publicity here, that has just been issued, although the rules are not to be published until tomorrow morning's papers. I will read a statement regarding this conservation order:

"UNITED STATES FUEL ADMINISTRATION,
WASHINGTON, D. C.

January 6, 1919.

STATEMENT REGARDING ORDER PROHIBITING THE USE OF NATURAL GAS IN ANY WASTEFUL MANNER.

The marketed production of natural gas in the United States amounts to about 800 billion cubic feet a year, serving about 10% of the population. This product takes the place of over 30,000,000 tons of coal. It is estimated that the wastage of natural gas is equal to the consumption, and that a conspicuous proportion of this loss results from practices which may readily be eradicated.

Owing to the magnitude of the service rendered by natural gas and the significance of the preventable losses taking place in its consumption, the conservation of this product is one of great importance, especially during the coming winter. The efforts of the Fuel Administration toward the conservation of natural gas have already effected a considerable saving translatable in terms of coal.

The natural gas situation has become steadily worse during the last few years. In many parts of the country at the present moment

it is critical; in many communities the consequences during the coming winter will be serious. The supply is beginning to run short, and only by the greatest vigilance and care can due service be obtained from the quantity available. The losses in connection with the use of natural gas are greater relatively than those of any other commodity, and many of these losses are subject to immediate improvement through enforcement of proper regualtions.

Prior to June 30, 1916, the production of natural gas in West Virginia for a number of years had been supporting the decline in output of Ohio, Indiana and Pennsylvania, where the seriousness of the situation is somewhat hidden by the supply imported from the neighboring state. But according to figures compiled by the Public Utilities Commission of West Virginia, the output in this state during the fiscal year ending June 30, 1917, declined, to the extent of about 12%, thus withdrawing this measure of its support from the States of Indiana, Ohio and Pennsylvania.

In view of such interrelation of consumption and production and the fact that a decline in available supply in a given community is usually hidden for a period through an overdraft upon more distant fields, the situation in the aggregate is capable of developing critical aspects with disastrous suddenness. The coincidence of national emergency with what would have ordinarily been a natural gas shortage has aggravated the situation and makes more essential a continuation of conservation measures.

The need for natural gas conservation is no better exemplified than in the case of Louisville, Ky. When, last winter, its supply of natural gas failed, it was found that 1.9% of the consumers were using 30.7% of the natural gas.

This was due in part to the consumption of natural gas in converted coal furnaces, wholly improper appliance for burning natural gas. Public Utilities Commissions are now prohibiting the use of natural gas in appliances not primarily constructed for such use.

Investigations by the Fuel Administration show that the wastage due to leakage in distributing systems has been enormous. In many cases, where meters were installed, it was found that the leakage ran as high as 50% of the total. The leakage in the consumers' house pipes is much larger than ordinarily appreciated. In houses where leakage has been checked, it has been found that the leakage averaged 19,000 cubic feet of gas per annum for each house. There are many distributing plants that waste more than one-third of the gas delivered at the gates of the town, and there are many main transmission lines where the percentage of leakage is very high.

A large number of open flame torches, or flambeaux, are still in use. This is not only an inefficient and wasteful method of securing illumination at night, but in many instances the torches are not shut off during the day, and this practice is especially reprehensible at the present time.

Where wells are blown into the atmosphere for water-freeing purposes, the gas, of necessity, is lost. However, in many cases the wells are blown longer than necessary, and in others it would be feasible to install special pumps for the removal of the water, so as to curtail this form of waste. A large proportion of waste is due to the fact

that in many communities cheap gas, or even free gas, is supplied for manufacturing. Where either is done, efficient devices are ordinarily not in use and a considerable improvement can be effected.

The so-called free gas feature has been especially troublesome and has resulted in depriving many domestic consumers of an adequate supply of the best fuel available for household use. In an extensive investigation of the amount of gas consumed by domestic consumers in West Virginia having this so-called free gas service privilege (on account of having gas wells or gas lines on their farms), it was found that the average consumption per free consumer a year was 480,000 cubic feet. This is a waste of at least 350,000 cubic feet for each free consumer a year. There are at least 4,400 free consumers in West Virginia, and at this rate of waste this item alone amounts to 1,540,000,000 cubic feet a year.

The following further emphasizes this form of waste:

> Average annual consumption for each free domestic natural gas consumer in West Virginia, 480 M.
>
> Average annual consumption for each domestic natural gas consumer in the United States, 100 M.

These few examples, which might be multiplied many times, will serve to show that the wastage in natural gas is notoriously high. Many points of wastage have been corrected and should continue to be held under a corrective influence.

Therefore, it is felt that the unique circumstances surrounding the matter of natural gas justify the enforcement of an order prohibiting the continuation of wasteful practices in the consumption of natural gas."

In view of the situation as developed by that statement, the following order has been issued by the Fuel Administration:

"UNITED STATES FUEL ADMINISTRATION,
WASHINGTON, D. C.

January 4, 1919.

IT APPEARING to the United States Fuel Administrator that the supply of natural gas throughout the United States is rapidly diminishing, and that a general shortage therein exists, and that it is necessary, therefore, in order to secure an adequate supply and equitable distribution, that all wasteful practices in the consumption of natural gas shall be eliminated,

THE UNITED STATES FUEL ADMINISTRATOR, acting under authority of an Executive Order of the President of the United States, dated 23 August, 1917, appointing said Administrator, and of subsequent Executive Orders, and in furtherance of the purpose of said Orders and of the Act of Congress therein referred to and approved August 10, 1917,

HEREBY MAKES AND ESTABLISHES the folowing regulation, effective January 8, 1919, and until further or other order, and subject to general or specific modification from time to time, and at any time:

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REGULATION

The use of natural gas in any wasteful manner is hereby prohibited. It shall be deemed wasteful to burn natural gas by means of flambeaux or open lights, to burn natural gas for the purpose of outside lighting during daylight hours, to burn natural gas in inefficient appliances; to burn more natural gas than is reasonably necessary for the purpose which it is intended to serve; or to consume natural gas in any other manner which is not reasonably efficient and economical. Licensees are hereby directed to report to the United States Fuel Administration all cases where consumers persist in the wasteful use of natural gas.

(Signed) H. A. GARFIELD,
United States Fuel Administrator."

This notice will be given out to the papers for publication on January 9, 1919:

"UNITED STATES FUEL ADMINISTRATION,
WASHINGTON, D. C.

January 7, 1919.

No. 976.

FOR RELEASE TO PAPERS OF THURSDAY, JANUARY 9, 1919.

FEDERAL ORDER FORBIDS WASTE OF NATURAL GAS.

Wasteful usages of natural gas, such as burning it all day to save the trouble of turning it off, are to be reported hereafter to the United States Fuel Administration, under an order promulgated today.

Existing shortages of natural gas may be alleviated in some measure, Fuel Administration officials said, by the order, which says:

> 'It shall be deemed wasteful to burn natural gas by means of flambeaux or open lights; to burn natural gas for the purpose of outside lighting during daylight hours; to burn natural gas in inefficient appliances; to burn more natural gas than is reasonably necessary for the purpose which it is intended to serve; or to consume natural gas in any other manner which is not reasonably efficient and economical. Licensees are hereby directed to report to the United States Fuel Administration all cases where consumers persist in the wasteful use of natural gas.'

The order was issued because of instances where natural gas was allowed to burn carelessly, even when under meter regulation, as well as for the guidance of so-called "free" consumers, whose gas costs them nothing, it was stated.

Various attempts were made during the autumn to persuade "free" consumers to limit themselves to 200,000 cubic feet a year, but these were unofficial as regards the Fuel Administration.

The marketed production of natural gas in the United States amounts to about 800,000,000,000 cubic feet a year, serving about 10 per cent. of the population. This production takes the place of over

30,000,000 tons of coal. It is estimated that the wastage of natural gas is equal to the consumption, and that a conspicuous proportion of this loss results from practices which may readily be eradicated.

The natural gas situation has become steadily worse during the last few years. In many parts of the country at the present moment it is critical; in many communities the consequences during the coming winter threatens to be serious. The supply is beginning to run short, and only by the greatest vigilance and care can due service be obtained from the quantity available. The losses in connection with use of natural gas are greater relatively than those of any other commodity, and many of these losses are subject to immediate improvement through enforcement of proper regulations.

As an example, it was pointed out that last winter in Louisville, Ky., when the supply of natural gas failed, it was found that 1.9% of the consumers were using 30.7% of the natural gas.

This was due in part to the consumption of natural gas in converted coal furnaces, a wholly improper appliance for burning natural gas according to Fuel Administration engineers. Public Utilities Commissions are now prohibiting the use of natural gas in appliances not primarily constructed for such use.

The so-called free gas feature has been especially troublesome and has resulted in depriving many domestic consumers of an adequate supply of the best fuel available for household use. In an extensive investigation of the amount of gas consumed by domestic consumers in West Virginia having this so-called free gas service privilege, (on account of having gas wells or gas lines on their farms), it was found that the average consumption per free consumer a year was 480,000 cubic feet. This is a waste of at least 350,000 cubic feet for each free consumer a year. There are at least 4,400 free consumers in West Virginia, and at this rate of waste this item alone amounts to 1,540,000,000 cubic feet a year.

The average annual consumption for each domestic natural gas consumer in the United States is 100,000 cubic feet.

Owing to the magnitude of the service rendered by natural gas and the significance of the preventable losses taking place in its consumption, the conservation of this product is one of great importance, especially during the coming winter. The efforts of the Fuel Administration toward the conservation of natural gas have already effected a considerable saving translatable in terms of coal."

In regard to the wasteful manner, I can see a number of inquiries that are going to come up for a ruling on this order. And as the activities of the Fuel Administration under the present law will cease on the signing of the Treaty of Peace, it will be necessary for the Public Utilities Commissions in the various states to continue activities along these lines; and I desire here to thank the Public Utilities Commissions of the various states who have co-operated with the Fuel Administration in every way, and we will ask that they continue the conservation measures stated on the natural gas situation, as the continuation of the conservation proposition will certainly determine whether the gas supply available to Pennsylvania is to be of short duration or lengthened a number of years by a continuation of these practices.

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COMMISSIONER RILLING: Mr. L. L. Graham, of Oil City, of the Pennsylvania and the United Natural Gas Companies, has made a deep study of the conservation of natural gas, and has kindly consented to prepare a paper and read it to us at this time. Mr. Graham.

Mr. Graham then read the folowing paper:

MR. COMMISSIONER: Of all the matters falling within the scope of the jurisdiction of the Public Service Commission of Pennsylvania, the questions relating to the public use of natural gas are of the greatest importance. There are several reasons why the natural gas questions before the Commission are of greater importance than any other question with which it has to deal; one of which, and probably the most important and principal one is, that the rules and regulations governing all other Public Service questions cannot be applied to, because they do not fit, the natural gas business; the reason for this being that the natural gas business deals with the question of marketing a commercial commodity owned and held by the person or corporation engaged in the business, and which, in carrying on the business, is turned over to the public in connection with its public service duties, distinguishing it from all other public service businesses.

In the preparation of this paper we have assumed that the Commission not only has jurisdiction over the service end of the business, namely, the transportation of the commodity from the wells where it is produced, to the market, and the delivery thereof to the consumer, but to the end that the question of conservation may be fully comprehended, that its jurisdiction extends to the commodity itself, in place, by whomsoever held or owned.

So now, with this understanding, we come to the question of the conservation of natural gas, and I start out with this proposition:

Had we had a Public Service Commission, or any other Tribunal, clothed with powers to control the use, as well as the methods employed in the transportation and use of natural gas, and it had exercised that power in such a manner that no gas could have been wasted, in the ordinary transportation and use thereof, since the beginning of the natural gas business, some thirty years ago, enough gas could have been saved to have supplied the same number of consumers with the same amount of gas for a like period.

In other words, expressing the thought differently, at least fifty per cent. of the natural gas produced and started for delivery to consumers, has been wasted, either in the loss of the gas, or in the inefficient methods of using it.

The question of the conservation of natural gas is of vital importance to a large part of the population of Western Pennsylvania.

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Throughout the natural gas section of Pennsylvania, the people are more interested in the question of the conservation of natural gas than they are in the conservation of any other commercial commodity used by them. The economical use and conservation of our vast coal commodity is an important matter. The economical use and conservation of our timber resources is an important matter. And so on with our many other commercial commodities. But above all else does our natural gas resources need our watchful care and attention. Particularly so because she is a tender baby, and because of her peculiar nature, she needs and must have our most careful attention; she is a frail little thing, prone to wander about, and will whiff away if she is not carefully guarded, and once gone she will never return. Profound men of our country, speaking of this commodity and its fugitive nature, have likened it in fancy to the wild birds and animals. But when you consider it in sober thought it is not so fanciful, after all; for even after you have captured it in the usual manner, by drilling wells, and have it packed in and capped over, even then it may escape or be drawn off through other openings, never to return. Compare this peculiar commercial commodity with other commodities that go to make up the vast resources of our State. Take for consideration, if you please, our great timber wealth. In a great measure it has been squandered and wasted. I am thinking now of the vast quantities of hemlock which at one time covered the Alleghenies, and which was cut solely for the bark it produced; while the timber, which we would now like to have and would prize so highly, was left to rot upon the ground, to the benefit of no man. But that commodity can be regrown, reproduced and replaced, and is now being reproduced in great quantities. The coal from our hills and the iron cannot be reproduced, but we can determine to a very accurate degree just how much we have and when it will be gone, and can replace it from other fields, remotely located.

It is quite different however, with our natural gas commodity. It cannot be regrown or replaced, and owing to its peculiar nature and its disposition to float away, disappear and be gone forever, it cannot be transported to a great distance, sold and delivered to consumers with the same faciilties as can other more stable commodities of commerce. Consequently, it must have our most devoted attention.

As we look back over the few years during which natural gas has been gathered and conveyed to market, with a full knowledge of the manner in which the business has been conducted, and a full knowledge of the methods and practices of the consumers in using gas, we are shocked when we realize what vast amounts of gas have been

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wasted; and we feel that it is now time that every one, the owner, the producer, the transporter and the consumer, should put forth every effort to save and conserve this most valuable commodity.

The owners of this natural gas commodity, in the early days, wasted vast amounts of it during the period of development, in allowing wells to stand open and blow off in the air. Large quantities of gas have been wasted in blowing fluids from the wells and lines. However, as regards this wasteful method, we are pleased to know that it has been eliminated, practically.

In the beginning of the natural gas business, natural gas was sold to the consumer at a flat rate, based upon the size of the orifice through which the gas passed into his mixer and it mattered not whether the gas flowed continuously or at intervals, the price paid was just the same. Consequently, the consumer had no thought that it was of any interest to him to curtail the amount of gas consumed; he had no thought that the time would come when he would long for the gas he was thus wasting. The institution of the gas meter for the purpose of measuring all the gas delivered to the consumer, and charging him accordingly, had a wonderful effect in saving gas.

During the early days of the natural gas business, it was not the question with the gas company, how many consumers can we supply, but how can we get sufficient consumers to market all the gas we have. Consequently lines were laid at a great distance, with the view of reaching all the consumers that could be reached, and gas was burned for any purpose where heat was desired. In many places lines were laid to outlying consumers, and are still in existence, where not to exceed 50 per cent. of the gas employed is ever delivered to the consumer; and we have no hesitancy in saying that in many places gas has been used, and is now being used, where tests would prove its percentage of efficiency to be very small.

The natural gas business in Pennsylvania has continued over a period of more than thirty years; and as we have intimated before, we state freely that there has been more gas wasted during those thirty years by the cosumers, and in the operation of wells and lines, to say nothing of the inevitable leakage, than would be required to supply the present consumers of Pennsylvania for a like period. We maintain that even though a consumer pays for all the gas that goes through his meter, in the interest of the public he has no right to waste it, or to consume more gas than would reasonably meet his requirements. It is a very ordinary thing, in traveling through the districts in which natural gas is used, to see street lights, store lights, and even lights about dwellings burning continuously day after day, simply because it is more convenient to allow them to burn, than it is to turn them off during the day and

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relight them at night. This is a waste of gas that should not be tolerated for a moment. It is a waste of a valuable commodity, and cannot possibly be of benefit to any one. It does not benefit the gas dealer, because it is of no benefit to him to have his gas burned when it benefits no one, and when it might be saved and sold where it would bring the consumer a benefit, any more than it would benefit the wheat dealer to have his wheat made into bread and thrown into the river, in the face of this knowledge that in the no distant future hungry mouths would be clamoring for it. Neither does it work beneficially to any one to have natural gas consumed in large quantities through appliances where the efficiency is of very small percentage. In fact, it is a crime against the gas consuming public to have such a valuable commodity wasted in such a manner.

It has been the practice of gas companies in the past to handle the gas in their delivery systems at a much higher pressure than is necessary to get the best results from the use of gas. This method has resulted in great waste, not only of the gas, through leakage due to high pressure, but it has been demonstrated, as a fact, by the most able people of our country, that greater benefits can be derived through the use of gas at a low pressure, than at a high pressure. So that while the gas has been wasted through leakage due to high pressure, the consumer has not received as much value from the gas consumed as he might otherwise have received.

Natural gas companies, holding large areas of prospective gas territory, have in the past endeavored to operate their territory in such a manner as would prolong the use of the gas to the utmost extent. In drilling territory they have located their wells in such a manner that all of the gas would be taken out eventually, slowly but surely. But as the demand for gas increased, and the supply diminished, they have been compelled in many instances to bore additional bung holes in the barrel, and take it out that much faster. This is not good for the gas consuming public, who have depended upon gas for fuel these many years. It simply hastens the inevitable end of natural gas.

I do not mean to intimate that the natural gas business is now ended, or that it will end for many years to come; but it goes without saying that it will end in time, and it is up to us now to put that day as far into the future as possible.

The attitude of the Public Service Commission of this State, as reflected in its inquiries as to present and future supply and conservation of supply, suggests that it is going into this matter in a way that great good may come of it.

The great difficulty with the natural gas business at the present time, grows out of the fact that the demand for natural gas is greater than the supply; consequently, in addition to the very great

question of conservation, connected with it we have the very important question of so using and applying the available supply, that the consumer may have a safe, fair and reasonable service.

The Commission has established rules governing the quality of gas that may be sold to the consumer, also the pressure at which it may be delivered. The question of quality does not come within the scope of the discussion of the question of conservation, but the matter of the rule of pressure does. However, all we propose to say here, in that connection is, that in the interest of economy and conservation, the rule governing pressure should limit the pressure at the outlet side of the consumer's meter to such a point as would produce the most economical results, and which at the same time would have the effect of reducing loss by leakage to the lowest possible point.

Unquestionably, a considerable portion of the complaints as to inefficient service is due to the consumer's inefficient appliances for using gas, rather than to the supply, it being very clear that at many times, and in many instances, the supply, when complained of, is sufficient, and is being delivered at a pressure which would be most advantageous to the consumer if his appliances were adequate and properly adjusted.

The question of regulating the use of gas with a view of conserving the supply, has many angles, but I believe it can be worked out practically. It is to the interest of all to do so. It goes without saying that the consumer desires to get the fullest benefit possible from the gas consumed. If he does get the full benefit, he will consume less gas, to the benefit of others and the future.

Let me suggest a few questions which are quite pertinent to the question under consideration:

How far can the matter of the use of natural gas be controlled?

How far can the owner or producer control the use, and how far can the owner or producer be controlled?

How far can the distributor control the use of natural gas?

How far can the Public Service Commission control its use?

How far can the purchaser control the use, or rather, how far can the purchaser be controlled in the use of this article of commerce when purchased by him?

These questions naturally arise in the discussion of conservation, because only if its use can be controlled, can it be conserved.

Another question, or rather, another angle of the question presents itself,—how far can we go in limiting the area over which this commodity shall be spread. As we all know, there is a great clamoring for natural gas wherever it may possibly be had. The reason for this is obvious. At times, most any where now, the demand is greater than the supply; in certain sections for many years gas

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companies have refused to extend their service lines, because they have been impressed with the idea that it was more desirable to give satisfactory service to a less number, than a poor service to a greater number; but that matter is now in the hands of the Commission.

Do not think for a moment that I am going to undertake to answer these questions, for I am not. What I have to say relative to the first question I say with all the fortitude I possess, fully realizing that my ideas do not harmonize with the ideas of some others. However, I say, that if the use of natural gas can be controlled, it should be controlled for the general interest, by confining its use to such purposes as will produce the greatest economical results, to be determined entirely upon the degree of efficiency obtainable. The fact being, as stated, that at no place, nowadays, is the supply equal to the demand the year round. It therefore logically follows, that whatever quantity is used for purposes that produce less than the maximum efficiency, creates a waste to that extent. If the question to be determined was left entirely to the owner of the commodity, and he should be paid on a basis of the value realized by the consumer, the question of conservation would be solved. In fairness to all then, should not the gas supply be conserved for the benefit of the use that produces the greatest value to the consumer? Great quantities of gas have been used, and no doubt are now being used, where the entire product is, in a sense, wasted; in the sense, of course, that the commodity is being turned over and burned up without adequate return being made for that which is consumed.

What is said here is not in any sense a discussion of rates. What we say about the value of the commodity cannot be taken as an expression of our view as to rates for service, value of commodity being one thing, and compensation for service being another. It is here predicted that before the natural gas conservation question can be solved, it will be necessary to draw a taut line between the two prominent features of the business, commodity and service—commodity value and service compensation.

As regards the second question, "how far can the owner or producer of natural gas control its use, or how far can the owner or producer be controlled," I am not answering, but only attempting to amplify the question. It will be observed that this question has a direct bearing upon the question of supply and the conservation of supply, and brings to view the features of the natural gas business, distinguishing it from other public service businesses.

Can an individual owner of natural gas, in place, be compelled to turn his commodity over to the public? Can even a natural gas company of Pennsylvania be compelled to produce and turn over its commodity to the public? If so, by what process?

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If the producing of natural gas can be controlled to the extent that competitive drilling can be eliminated, it will add greatly to the life of the business. If the drilling of only the necessary number of wells within a given area, sufficient to produce all of the gas within a reasonable time can be controlled, it will conserve the supply; but it is doubtful if any fixed rule could be established that would be satisfactory in this regard.

The remaining questions might better be disposed of collectively. If the distributor were in a position to say to whom he would deliver gas, and for what purposes it could be used, he could, if he were so disposed, see to it that it was only used for purposes where its greatest value could be enjoyed, which would surely conserve the supply.

If the Commission can regulate the use of gas, and the manner of using as well, and it should be so, to the end that the supply should be devoted to such use only as would produce the greatest benefit to the consumer, the supply would be conserved.

As I look at it, if the commodity is used, even to exhaustion, in such a manner as will produce to the consumer all the value it is capable of producing—none wasted—it has been conserved to the utmost degree.

As I have intimated, it is my desire to avoid any allusion to the matters of rates in this paper; notwithstanding the fact that rates may suggest conservation, and conservation may suggest rates. In this connection I want to propound this enigma:

The consumer ordinarily pays, in the aggregate, twice as much for gas as he should; nevertheless, for every dollar the distributor of gas has profited, the consumer thereof has profited two dollars. Let it be understood, however, that I have in mind the high efficiency user, not the user who has been permitted to use the gas simply for the purpose of keeping up business and swelling the receipts of the distributor regardless of value. For instance, if the domestic and gas engine consumers of natural gas have not obtained their fuel at less than 50 per cent. of what it would have cost them for other fuel and power, it is their own fault. Take for consideration the use of natural gas for cooking purposes. If it is used through efficient appliances, at the proper pressure, and the flow is turned off when the work is accomplished, the cost to the consumer in comparison with any other fuel is insignificant, and I make this statement for comparison. If the consumer were to pay three times the price that has ever been paid in Pennsylvania, it would still be the cheapest fuel obtainable. We have absolute authority for this statement. We refer you to Mr. Wyer.

In closing I offer the following suggestions, looking to the conservation of natural gas:

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First: That the supply of natural gas be limited to the uses producing the greatest efficiency.

Second: That all field operations be conducted in a manner calculated to produce the greatest volume for the longest period of time, and that competitive drilling be discouraged.

Third: That the sale of gas by the distributor, solely for the purpose of keeping up receipts, regardless of the value of the commodity, be discouraged.

Fourth: The eliminating of lines now laid to great distances from main lines and plants where a large percentage of waste is unavoidable; and that the laying of such lines and the extension of plants be prohibited in all cases where the supply is not sufficient to meet the demands at all times.

Fifth: That the use of natural gas for street lighting purposes be discouraged generally, and positively prohibited where they are allowed to burn continuously.

Sixth: That a referee or inspector be appointed, who may have authority under the Commission to investigate and report to the Commission on all matters having a bearing upon the question of the conservation of natural gas, and the enforcement of regulations adopted for that purpose.

COMMISSIONER RILLING: I am sure we have listened to this very interesting paper by Mr. Graham with much pleasure, and while Mr. Graham is a modest man, I am sure he will endeavor to answer any questions that any person may wish to ask him. This meeting is for the purpose of informing ourselves on this important subject, and if there is anyone here who desires to ask Mr. Graham any question in relation to his paper, we will be very glad to accord him the privilege at this time of so doing. If not, we will now listen to an address by John Gates, Esq., of the Philadelphia Company, on the natural gas industry in Pennsylvania.

MR. GATES: Mr. Chairman, Gentlemen:—The subject of this paper is "The Future of Gas Service in Pittsburgh and in the Pittsburgh District." I might say that it was written with the idea that the meeting would have had before it the paper of Mr. Wyer, showing the depletion of the gas fields, and the purpose of this paper was to reassure the consumers of gas as far as it was possible to do so, with respect to their future supply.

Over a million and a half people in what is generally known as the Pittsburgh District of Western Pennsylvania are dependent for their fuel upon the natural gas companies. Many of these consumers not only use natural gas for their fuel requirements, but also for light and for power.

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Throughtout this vast army of gas consumers there has recently been spread a feeling of grave apprehension. They fear that the producing companies have exhausted their sources of supply. They dread to replace gas with coal, but feel that such a change must be made, and that very soon. Many have already experienced a shortage and all have read newspaper articles setting forth at length the depletion of the natural gas fields.

"For how long can we depend upon your company for natural gas service?" This is a familiar question. The object of this paper is to answer that question. The answer, however, will not be an exact one. The nature of the natural gas industry prevents accurate predictions. Unfortunate (unlike other public utilities) natural gas companies must depend for their product upon chance. The drilling of gas wells is a hazardous business, just as all mining ventures, by their nature, must be. The best way to answer the question seems to be to present certain facts with regard to the industry and then to point out the probable development of natural gas service.

The marketing companies supply two classes of consumers, the domestic consumers and the industrial consumers. The domestic consumer uses gas in the home for cooking, heating and lighting. The industrial consumer uses gas, usually in large quantities, for fuel and power in mills and manufactories. There are other small classes of consumers, but these two are sufficient for our purpose.

In Pittsburgh and in the territory surrounding it, natural gas has been sold by the following named companies during the twelve months ended December 1st, 1918, to domestic and industrial consumers in the following amounts:

Name of the Company.	Number of domestic consumers December 1st, 1918.	Cubic feet of gas sold to domestics during 12 mos. ended 12-1-18.	Number of Industrial consumers December 1st, 1918.	Cubic feet of gas sold to industrials during 12 mos. ended 12-1-18.
Phila. Co. and affiliaated Companies (Penna only),	144,101	20,125,332,000	419	20,601,357,000
Peoples Natural Gas Co.,	75,981	10,022,140,000	150	16,628,983,000
Manufacturers Light and Heat Company, (Penna. only),	69,271	8,232,325,000	258	7,681,206,000
Phillips Oil & Gas Company,	17,611	2,028,581,000	199	8,670,284,000
Greensboro Gas Company,	18,706	1,687,816,000	22	3,501,531,000
American Natural Gas Company,	14,064	1,641,782,000	57	5,681,644,000
Totals,	339,734	43,737,976,000	1,105	62,765,005,000

It is a fact, not generally understood, that the industrial sales of natural gas are very much in excess of the domestic sales. This

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industrial percentage would be greatly increased if the sales of the Carnegie Natural Gas Company were included in the calculations.

Gas companies have always given preference to the domestic consumers, applying the familiar law of the sea, "Women and children first." We are therefore safe in saying that the sales of natural gas to industrial consumers during the winter season must in the future be decreased in volume in proportion to the decrease in the available supply.

In considering the future supply of gas to the householder there are two important considerations. The first is the industrial service we have just mentioned, and the second is the peak load problem. The monthly sales of gas for the year ended December 1st, 1918, by the proprietary companies of the Philadelphia Company were as follows:

PENNSYLVANIA ONLY.

Month.	Domestic Sales. M. Cu. Ft.	Percentage by Months.	Industrial Sales. M. Cu. Ft.	Percentage by Months.
1917.				
December,	2,702,629	13.4	1,228,065	6
1918.				
January,	3,656,552	18.2	530,867	2.6
February,	3,164,442	15.7	960,285	4.5
March,	2,338,987	11.6	1,632,647	7.9
April,	1,737,689	8.6	1,763,280	8.6
May,	1,253,523	6.2	2,013,291	9.8
June,	777,867	3.9	2,007,260	9.7
July,	718,845	3.6	2,126,795	10.3
August,	588,095	2.9	2,288,017	11.2
September,	684,095	3.4	2,157,709	10.5
October,	1,042,462	5.2	2,135,305	10.4
November,	1,459,989	7.3	1,757,336	8.5
Totals,	20,125,332	100.0	20,601,357	100.0

It will be noted that the industrial sales would continue very steady at about nine per cent. a month if it were not the cut in January and December and in February, because their gas was discontinued to deliver to domestic consumers.

The average amount of gas sold daily to a domestic consumer can be roughly estimated at one hundred twenty-five cubic feet on a hot summer day and at one thousand cubic feet on a cold winter day, a ratio of one to eight (some companies report this proportion to be as one to nine and others as high as one to ten). This means that the distributing company must prepare during the summer months to do a domestic business in the winter months eight times the volume of its summer domestic business. This is the chief trouble of the gas man. All utilities have peak load problems, but none of them have such extremes in the volume of their business.

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We are therefore safe in saying that this peak load must be lightened, and the domestic curve on the chart must not come to so acute a point as heretofore. This is caused by the turning on, full force, of every heating furnace in the district at the same time. In the years to come there will not be gas enough at such times to go around. This is true at the present time in some localities, even after the industrial supply has been greatly curtailed or entirely eliminated. It then becomes a question of using some auxiliary fuel to help out in times of peak load. Sometimes an occasional coal or wood fire in a single room of the house will suffice. Sometimes an oil stove will tide the householder over periods of great demand. Some gas is now burned in old coal furnaces, with wasteful burners. As the price of gas advances, gas furnaces, with the most efficient burners, will replace this wasteful equipment and furnish the same amount of heat with possibly one-third less gas. Thus gas consumers can enjoy this fuel for probably three hundred and fifty days in the year, supplementing it, if necessary, with an auxiliary fuel on the other fifteen days.

The Philadelphia Company, through one of its proprietary companies, the Equitable Gas Company, has already constructed, at Elrama, Pennsylvania, an experimental plant for the manufacture of gas, and it is there testing out a plan of supplementing with artificial gas its supply of natural gas. It is the intention of this company to increase its artificial gas supply year by year as the needs of its domestic consumers may require. Its plans call for the construction of plants for the manufacture of artificial gas in quantities which will increase in proportion to the depletion of the natural gas fields.

Although the gas companies are selling over 58.9 per cent. of their total supply to steel mills, manufactories, etc., such service is not considered to be their public service. Fuel is but one of the raw materials used in a mill. Gas is in demand because of its cleanliness, cheapness and adaptability. One Pittsburgh steel company has used an average of $24,000,000 cubic feet of gas per day during the last six months and 24,000,000 cubic feet of gas is an amount sufficient to supply 192,000 families on a summer day and 24,000 families on a winter day. Such a sale is surely not a public service. Gas companies have not held themselves out as being able to supply industrial gas in winter. Industrial contracts usually contain a clause similar to the following: "The company shall have the right to discontinue the supply of gas temporarily or permanently whenever it shall be necessary to do so in order to deliver a full supply of gas for domestic consumption." Gas companies have been selling domestic gas for the past ten years at from 27½c to 30c per 1,000 cubic feet, because their enormous industrial sales

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have provided funds for a large portion of their expenditures and thus enabled them to maintain this low rate. When the industrial service is discontinued the domestic service will of course have to carry the entire operating expense. For many years to come, however, we will continue to supply the industries during moderate weather. In fact, for financial reason we must dispose of our big summer surplus to industrial consumers. If we do not do this we will be unable to provide a sufficient supply of gas in winter for furnace use by domestic consumers.

In this paper I am assuming that there has been shown or will be shown in the conference today by the most convincing proof the following facts:

1st. That the rock pressure in the gas fields of Pennsylvania and West Virginia has fallen off in many cases from 50% to 75%.

2nd. That the average original volume of new wells drilled has fallen off approximately 50% in the last five years, and that the percentage of dry holes has greatly increased.

3rd. That owing to the fact that the companies are going each year further and further afield in their efforts to secure gas, and also owing to the fact that the pressures in the transportation systems have been greatly reduced, the companies have been compelled to increase greatly the engine horse power of their compressing stations, in order to supply the demands of their consumers.

4th. That the gross amount of natural gas available for sale in the Pittsburgh District will grow less and less as the years go by.

Notwithstanding these facts, we wish (and in the remainder of this paper I can, of course, speak with authority for my own company only)—notwithstanding these facts, we wish to retain our business of taking care of the fuel requirements of over 700,000 persons (counting five each to our 144,000 domestic contracts). We have been furnishing gas in Pittsburgh for over thirty-four years under an ordinance approved July 31st, 1884. Upon several occasions during that time our gas fields were far less promising than at the present time. We are optimistic enough to believe that twenty years from now we will still be marketing natural gas in Pittsburgh. It will be in greatly diminished quantities, but commingled with the artificial product it will continue in the future as in the past to give Pittsburgh a decided fuel advantage over other cities. Most of our gas comes from West Virginia, and that state in 1917 lead the world in natural gas production. Its production in that year was 291,501,784,000 cubic feet of gas. This was doubtless the highest mark in natural gas production that will ever be recorded by that wonderful state, as the production for 1918 is over sixteen billion cubic feet less than that amount. That, however, does not mean that its gas resources are at an end. Some of

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our Murrysville wells have been connected to our transportation lines and producing gas constantly for over thirty years, and no doubt some of our newly drilled wells will continue to produce, although in greatly reduced volume, for the next ten or fifteen years.

We need and we ask for the friendly co-operation of both classes of our consumers. Our industrial consumers we urge to use gas in quantity during the summer months and to secure other fuel for use in the winter months. They are able to do this. In fact, they are doing it now. Our domestic consumers we ask to use the most approved gas appliances, to conserve gas, and to provide some additional fuel for use in emergencies. Having this co-operation, we can face the future with confidence. Although speaking, in this respect, only for my own company, I feel sure that Pittsburgh need not worry over its future gas supply.

Our consumers want gas service and we expect to supply it. We will secure for them a supply of natural gas as long as it is obtainable. Then as the natural gas supply becomes depleted, we will supplement it more and more with the artificial product, continuing to do so indefinitely, or so long as gas remains as it is today, the most desirable fuel in the world.

COMMISSIONER RILLING: It is now nearly 12 o'clock. I think we will reserve one of our heavy guns for our afternoon session at 2 o'clock. That leaves a half an hour now, which we would like to have consumed by those present if they have anything to say or any suggestions to offer me. I see before me a very large number of people who are not only able but who are interested in this subject, and I am sure we would like to hear from anyone present, or if there are any questions to be asked of any of the three speakers who have addressed us this morning, I am sure the speakers would be glad to answer them. I do not want to call upon any person unless I am obliged to do so, so I ask you not to be backward about coming forward and giving us the benefit of such thoughts as you may have on the subject.

MR. WITTMER: I would like to ask the gentleman who last spoke (Mr. Gates), if the artificial gas he has in mind is a fixed gas? I am not well informed about the artificial gases. I would like to ask him if the gas is perfected so that it can be transported. I have always understood that artificial gases are not transportable over long distances. I would like to also ask him what efficiency they find it lacks, and what they must use for that?

MR. GATES: If the Commission please, we have with us today Mr. Carroll Miller, who is general manager of the company I rep-

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resent, and I am sure that matters of that sort he can explain better than I. He can answer those questions much better than I can.

MR. CARROLL MILLER: Mr. Commissioner and Gentlemen:—I had no idea of speaking on this occasion, but as Mr. Gates has called on me, I will say as briefly as possible a few words in regard to the manufactured or artificial gas, as it is generally known.

The gentlemen here asked in the first place about the transportation qualities of it. Artificial gas can be transported just as well and just as far as natural gas. There are several kinds, generally speaking. There is what is known as producer gas, water gas, which is either known as blue water gas or carburetted water gas—carburetted water gas is enriched with oil,—and then coal gas, which may be produced from coke ovens or in retorts. Any one of those gases can be transported as readily as natural gas, but on compression the coal gas and carburetted gas will lose a small proportion of the heat units,—maybe they will loose ten, or fifteen, or twenty heat units, depending on the pressure.

We are now in an emergency, for emergency puposes only, making what is known as producer gas. We will start in next spring building coke ovens for water gas, or both, not carburetted water gas. No company, at present at least, can afford to sell gas at 35 cents, or 40 cents, for that matter, and put in four gallons of oil per thousand,—all you gentlemen know that—which is about the amount that is ordinarily put into carburetted water gas, to bring the heat units up to 600. Producer gas is ordinarily known as having heat units of 120 to 160 per cubic foot. Blue water gas has 300 heat units. Carburetted water gas may have from 500 to 700, according to the amount of oil you put into it. Coal gas will vary from 500 to 600 heat units.

As Mr. Gates says, we propose to furnish our trade with gas. It is our duty as well as good business proposition, to furnish the gas that we can manufacture cheapest per heat unit. It remains to be seen what price that gas is to be sold at; but the heat units of the mixture must come down, and of course it will be very gradual.

I have estimated—this, of course, is subject to revision, but just to give you an idea—that possibly ten years from now we will be producing maybe 40 to 50 per cent. of the natural gas we are producing today, and we will be supplementing that with artificial gas, and the result in heat units will be anywhere from 800 to a thousand—I cannot tell; we cannot prophesy so far ahead, what gas we will make. We will start out with our program and maybe change it, but we will supply the gas, and we must supply gas, in almost equal quantities to industrials in the summmer as we do to the domestic in the winter, otherwise we would have to charge an exorbitant price to keep the

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heating business of the domestic consumer. In other words, as Mr. Gates said, the ratio of the heating or the domestic consumption to that in the winter is about one to eight. If we had to maintain a plant to supply that consumption in the winter, why, two dollars for gas would not be far out. You could not get a return on your investment. I say that to illustrate what Mr. Gates meant by its being absolutely necessary to have industrial gas to pay for the domestic gas, so to speak. But I wish to assure our customers at least that we are going to take care of them as long as they can use gas, and at as cheap a rate as possible, when everything is taken into consideration.

COMMISSIONER RILLING: Are there any further questions that anybody desires to ask any of the speakers?

MR. W. T. PHILLIPS, President of Philips Oil and Gas Company: We have had two excellent papers this morning, but each seem to have failed to bring out the fact that the percentage of gas used by domestic consumers in the winter months as compared with the summer months, does not tell the whole story. You have to take a cold day in the winter and compare it with a hot day in the summer, in order to measure the difference. Not only that, but you have to take a part of the full day in the winter, when the drawing is the heaviest, say at eight or nine o'clock in the morning, and compare that with a warm day in the summer. I think that Mr. Miller has brought out the idea very plainly that the industrial consumption is absolutely necessary at the present time, in order to run a gas plant. To cut that out would be fatal. It would force the price for domestic gas up so high that it would not be used.

MR. ELISHA K. KANE: I think that the matter of the cold morning may in general be disregarded, because there is a certain amount of storage in wells and lines, which will overcome that. The cold day is really the peak load that our companies seem to have found trying, rather than the cold morning.

MR. GREGORY: Mr. Kane, is not the heat requirement still there, even if you have the capacity for it

MR. KANE: Well, the heat requirement seems to be the whole day, because if we have well capacity of eight times—and that is what was shown before us here—if we have well capacity of eight times our average summer day, that is sufficient, by the warmth of the evening and the storage taking place during the night, to overcome the extra consumption in the cold morning. The morning is practically always the coldest time of the day, and it immediately follows the night, in which the consumption is arrested. We find at about ten to eleven

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o'clock at night consumption reaches its minimum—that is, I should say, exhaustion on our line reaching its greatest amount, and that is peculiar, because one would naturally think it would be around towards three o'clock when the coldest time comes; but in our experience it is about eleven o'clock at night that the greatest—that is, that the gas accumulates the most strongly. Then we have with the opening up about six o'clock in the morning—six to eight o'clock—is the greatest exhaustion. I take it that is the situation found everywhere. That is the time of the peak load, but it is not the peak load for which we need to provide well expansion, on account of this storage taking place anywhere from nine to three and four in the morning.

MR. GREGORY: Leave out whether it is any particular hour's peak load, and take a twenty-four hour peak load; take an excessive day in the winter or an excessive day in the summer, is it not much more than eight times?

MR. KANE: Well, the paper read here before us indicated that eight times was the amount, and that is what we have thought it was—four times for the average winter day against the average summer day, and eight times for the peak load day.

MR. GREGORY: What is Mr. Wyer's test on that, on the excessive demand on an excessive day and a minimum day in the summer?

MR. WYER: One danger in connection with the statement that has been made is that you are comparing the experience of a small plant with a small number of wells, a short transmission line, probably merely gathering lines, with general problems of public utiities generally, with their large market, anywhere from one to three hundred miles away from the field, under conditions that are not comparable at all. I do not believe that the storage capacity either in the wells or the lines, counting the lines as extending from the field clear into the consumer's premises, can give you any substantial relief to take care of a series of cold days, for the very simple reason that the wells will not yield, and you cannot fill the lines—speaking now of the transmission lines as a whole—and operate on a large scale for large markets, and many miles, frequently several hundred miles, distant from the field.

MR. MCNARNEY: I do not know much about natural gas, except that we get very poor service, and I may ask some very foolish questions; but I would like to find out some things. The first question I would like to ask Mr. Wyer is this: We have, in a town where we use natural gas, the regulator just outside of town; the pressure of

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gas above the regulator runs anywhere from twelve to fifteen pounds; when that passes through the regulator, the gas company tells us that they cannot get anywhere from an ounce to three or four ounces. Why is that?

MR. WYER: I wil answer the questions just as you raise them. If you have fifty pounds on the high side of the regulator, you can, of course, by opening the regulator wide, get the same pressure on the other side. If at any time you have a gas shortage and you are unable to get satisfactory pressure at the consumers' fixtures, you have one of two things facing you: In the first place, either your gas supply is so far gone in that particular community that you do not have the high pressure on the high side of the regulator to get the conditions that you outlined.

MR. MCNARNEY: That we have.

MR. WYER: Or it is necessary to keep a higher pressure on the high side, in order to give equitable distribution to other communities. What I mean by that is, that a community situated in the field, you could not open up the gate wide and simply let them have all of the gas that they could possibly get into their lines, and attempt to get any service at all to other communities two or three miles away.

MR. MCNARNEY: We are the last community on the line.

MR. WYER: Then you do not have fifty pounds on the high pressure side and only a few ounces on the low pressure side, except in such cases where the service line or the distributing line is entirely too small for the service. There is a mistake somewhere.

MR. MCNARNEY: Another question: Why is it that when we are not getting any gas the meter registers such as many thousand feet as when we are getting gas?

A VOICE: It's just owing to who reads it.

COMMISSIONER RILLING: Mr. Wyer, are you equal to that question?

MR. WYER: I just want to get a reference to refer you to. (Referring to Smithsonian Bulletin.) In the first place, the statement which you make is not in accordance with the facts. This is not in the spirit of contradicting you. When gas passes the meter, if the consumer utilizes it, he can get some form of usable service; or,

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to state it this way, the popular impression is precisely as you have stated, namely, that in periods of gas shortage the meter runs faster and that the consumer does not have the gas. The whole problem is that the consumer wants very much more gas than the system can possibly furnish. He does not get enough to satisfy his wants, and therefore he assumes that he is not getting any. For instance, in cooking operations, with very low pressure, the pressure down as low as two-tenths of an ounce, the meter will register the amount of gas passing through the meter and passing through the burner. If the householder is trying to cook on the ordinary gas range with that two-tenths of an ounce pressure, and heating the vessel on top of the stove, the statement which you make is an absolutely true one; the meter will register the gas, the gas will burn, and the stove operator will be absolutely unable to cook. However, if when that condition comes, you will bring that short flame up to the vessel, or the vessel down to the short flame, you can broil a beeksteak in practically the same time, and do it just as satisfactorily, with two-tenths of an ounce pressure, which is a flame a quarter of an inch long, as you can do with six ounces and a flame three or four inches long—a statement based on experiment and proof.

MR. MCNARNEY: Another question. Why wouldn't it be fair to everybody to charge by heat units instead of by thousand feet?

MR. WYER: In the first place, natural gas is a natural product and the gas company and the Utiltiy Commission or anyone else, have absolutely no power over its composition. Just as soon as you set up artificial arbitrary heating value standards, you no longer have a natural product, but a modified natural product, or an artificial product. However, to carry your point a little bit farther, if that were the case, the mere fact is that as to the gas distributed in West Virginia and the western part of Pennsylvania, the rates would then be the highest in the country, for the reason that the heating value of the West Virginia gas, which is used so generally in Pennsylvania, is the highest heating value of any gas in the world.

MR. MCNARNEY: Now, I want to ask another question; it may be a silly one, I don't know; but I have heard it said this is done: Can the gasoline be taken out of the gas and then the residuum put back into the pipes and sent to the consumer?

MR. WYER: It not only can be done but it ought to be made obligatory.

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MR. MCNARNEY: Why?

MR. WYER: Because it improves the quality of the service. This you will find discussed on page 25 of the Smithsonian Bulletin, which is part of this paper.

MR. MCNARNEY: Some one said, and I think it is in your book, that the proper amount of gas for an ordinary house to consume per month is about a thousand feet a day. Last January I paid for 80,000 feet. Why?

MR. WYER: Well, the first reason is that that much gas passed through the meter.

MR. MCNARNEY: Well, I didn't have any gas.

MR. WYER: You had gas. It is a question of proper utilization. In what sort of heating apparatus are you using gas?

MR. MCNAREY: I am using it in the ordinary gas stoves that are sold in all parts of the country.

MR. WYER: For instance, in the cooking stove, have you the ordinary gas range?

MR. MCNARNEY: I am using it, yes.

MR. WYER: As a starter on that,—That ordinary natural gas range wastes eighty-five per cent. of the gas delivered to it. Now, what sort of arrangement do you have for your heating stoves; or do you have a furnace, and if so, what sort is it?

MR. MCNARNEY: I have no furnace, I don't use a furnace. The house has thirteen rooms in it, and I am using all the time about six fires.

MR. WYER: What month in the year was it you said you used the 80,000 feet?

MR. MCNARNEY: That was last January—January, 1918.

MR. WYER: At what rate per thousand do you pay?

MR. MCNARNEY: At twenty-seven cents.

MR. WYER: Do you think you can compete with that feature in price of any coal that you can get, in heating a thirteen room house?

MR. MCNARNEY: I don't mean that. You said that a thousand feet a day was a proper amount. Now, I used nearly 3,000 feet,—or I paid for 3,000 feet.

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MR. WYER: A thousand feet was the amount fixed for one community, and the community, you will see by referring to page 36 of that Smithsonian report, has never been on an extensive heating basis. A thousand feet a day would not be enough in an old-fashioned natural gas town. A thousand feet a day was fixed in that community, because it was all the gas there was—not that it was what they ought to have had.

MR. MCNARNEY: One more question. Where can information be obtained as to efficient methods for using natural gas? That is, I mean specially efficient appliances for using natural gas?

MR. WYER: There are relatively few efficient natural gas using appliances. The ordinary coal furnace, such as is used for burning coal, in which, my judgment, based on a rather extensive study of the entire situation, would be that 85 to 90 per cent. of all of the gas used in furnace heating is burned, wastes 75 per cent. of the gas delivered to that furnace. That is, the thermal efficiency of the furnace is 25 per cent., and 75 per cent. of the heat energy goes up the chimney.

MR. MCNARNEY: My question is particularly with reference to stoves, not furnaces; because very few persons in our town use furnaces.

MR. WYER: Most heating stoves are inefficient, as most natural gas stoves are inefficient, although as a general proposition, the heating efficiency of a gas stove will be more than the heating efficiency of the ordinary furnace in which natural gas is used, for the simple reason that your radiating processes get into the room that you want to heat.

MR. MCNARNEY: Where can one get the best stove for heating purposes, using natural gas,—one that will be efficient in operation?

MR. WYER: I cannot answer that question publicly. There are several stoves and appliances on the market that give a very high degree of efficiency.

MR. MCNARNEY: Will you answer that privately?

MR. WYER: I will give that information privately.

MR. WILLIAM HORNE: I heard the order read, wherein each consumer would be allowed 24,000 feet of gas per month. I was wondering—I have often been asked, what is the penalty should a man burn more? For instance, I may have a large home; I have the hot water heating system; it involves, in order to save the gas, using

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wood in our furnace, and nevertheless—we have a twelve room house— in the past month we ran a little over our ratio; yet our neighbor, with a small house, with a small family, only, used half of what he might have used if he needed it. I was merely wondering what penalty should come to the larger user, other than paying for the gas he used?

COMMISSIONER RILLING: Mr. Gregory, can you tell the gentleman how long he would be put in jail if he uses more than 24,000 feet?

MR. GREGORY: He is liable to lose the supply of gas. That would be the only penalty. He would be liable to lose his future supply of gas.

MR. D. B. HEINER: Is that order in force in Pennsylvania or in New York?

MR. GREGORY: That is a Pennsylvania order.

MR. HEINER: It is not in force in New York?

MR. GREGORY: No. That order for the Potter Gas Company is not a general order, but just an order available to the Potter Gas Company.

(Recess was taken to two o'clock, P. M., or the same day, at which hour the Conference reconvened. There were present Commissioner Rilling and representatives and parties interested as before.)

COMMISSONER RILLING: Gentlemen, we will now have the pleasure of listening to Mr. Wyer, formerly chief, Natural Gas Conservation U. S. Fuel Administration.

MR. WYER: Mr. Chairman and Gentlemen: We had prepared a series of lantern slides that would have shown in larger scale the same illustrations that we have in the printed report. However, the conditions in the room will not permit the use of the lantern, and it will therefore be necessary to get along with the printed report (copy of this report is annexed hereto).

Rather than read the printed report, I will begin at the beginning and refer to the various high points in the text and in the illustrations. By way of introduction, the high points of the whole conservation question, as well as the high points of the particular Pennsylvania situation, are covered in concise form on pages 3 and 4 of the printed report.

One feature that is not ordinarily appreciated is that the conservation question is not a new one. To emphasize that, I wish to

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refer to the relatively long list of the United States Government publications on the subject of conservation, which are listed on page 8 of the report.

The characteristics of the natural gas situation may be stated as follows: Natural gas is becoming scarce. The demands for natural gas are now greater than the available supply. The fundamental principles underlying not only the whole conservation question but the matter of service, as far as this Pennsylvania situation is concerned, are discussed in a recent bulletin of the Smithsonian Institution. Rather than repeat, references will be made from time to time to various pages in that bulletin, where a more detailed discussion can be obtained.

The most important feature of the Pennsylvania gas situation is shown in graphical form on page 11, and brings out very emphatically the state's dependence on imported natural gas, most of that imported natural gas coming from West Virginia, the total amount of gas exported being relatively a very small per cent. of the total production, and of course a very small per cent. of the total amount of gas imported. The relationship is shown on page 11, beginning with the year 1906, and extending through to 1916, the latest available data, as far as the United States Geological Survey Statistics are concerned.

Another interesting comparison on page 11 will be noticed in comparing the smallness of the domestic consumers' gas with the total gas consumption in the state. This is due to the fact that such a relatively large percentage of the total amount of gas used in the state is used in industrial service.

At this point, I would like to state that if as we proceed anyone has any questions to ask, I would be very glad to answer them as we discuss the various curves, believing that that might be more satisfactory than to let all the questions accumulate until the end. There are some eighty charts in this report, and of course it will be necessary to hurry along in order to get through. Therefore, if any of you have any questions at any time regarding any phase of the discussion, if I can furnish the information, I would be very glad to do so.

A second phase of the Pennsylvania situation is discussed on page 12, where we have the relationship of the production and consumption and import of gas for the Peoples National Gas Company. This record begins in 1911 and is carried through to the end of 1917. Some one may be curious to know why in these illustrations as well as all of the illustrations that will follow, we have carried the years out to 1920. This report was prepared very hurriedly by merely assembling data previously worked up for private and governmental purposes, and at the time these plattings were worked

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up, it, was the intention, and it is the intention now, to keep tab on the changed situation of some of these companies, by platting the data we have here from year to year; and for that reason, in order to avoid the necessity of making new tracings, the additional years were put on, so that three additional years can be platted on these same tracings, as soon as the data becomes available.

The upper shaded area there (p. 12) represents the amount of gas produced in the state, and the lower shaded area, which is by far the larger of the two, represents the amount of gas imported from West Virginia. This is merely another illustration as to why you cannot discuss the Pennsylvania Natural gas situation without discussing the West Virginia field conditions.

On page 13, and following ten for a number of pages, we have a series of curves that show the decline in rock pressure of typical wells in typical natural gas working districts. On page 13 we have three typical rock pressure, decline curves of the Hope Natural Gas Company's wells, in Doddridge County, West Virginia. The highest rock pressure indicated by the heavy line there is about 725 pounds. This was in the year 1902. That particular well has declined so that at the end of 1917 the rock pressure was down to about 92 pounds. The other two wells shown on this same sheet had a lower initial pressure, but have also dropped down to relatively low pressures at the present time.

On page 14, we have three rock pressure decline curves of the Hope Natural Gas Company's wells, in Harrison County, West Virginia. There the highest rock pressure that is recorded is about 815 pounds, and that from 1904 down to 1917 dropped down to about 140 pounds. The other two wells which have lower initial pressures have all declined, and the rock pressures now, of course, are very much lower.

On page 15, we have a series of three rock pressure decline curves of the Hope Natural Gas Company's wells in Lewis County, West Virginia, in the heart, probably, of the finest natural gas territory that has ever been developed. There the highest rock pressure was about 1,040 in 1903, and that has dropped down to 348 pounds in 1917. The other two wells, both with lower initial pressures, have declined very much more than the well just referred to.

On page 16, we have the rock pressure decline of three typical wells of the Hope Natural Gas Company, in Marion County, West Virginia. There the rock pressure has dropped from about 955 pounds down to about 60 pounds.

On page 17, we have three typical rock pressure decline curves of wells in Monongalia County, West Virginia. The maximum pressure there was slightly under a thousand pounds, and that has dropped down to about 50 pounds at the present time.

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On page 18, there are three rock pressure decline curves of wells of the Hope Natural Gas Company in Wetzel County, West Virginia. Here we have a maximum pressure of about 1,100 pounds in 1900, which has declined to about 75 pounds in 1917.

Now, going over to some of the available records for Pennsylvania territory, on page 19 we have rock pressure decline curves of three wells in Westmoreland County, of The Peoples Natural Gas Company. Here we had a maximum pressure close to 1,500 pounds that has dropped down to slightly under 700 pounds. The other well which came in earlier, in the fifth sand—that is, came in in 1907—has dropped down to about 25 pounds.

On page 20, we have three rock pressure decline curves—three in Allegheny County. Note that here the initial pressure is relatively low, and that the decline has also been very marked. On page 21, we have the rock pressure decline of some wells in Armstrong County. Here the wells were started out with relatively low initial pressures, in comparison with wells in some of the West Virginia territory, and they are all down to a very low basis at the present time.

On page 22 we have the record of two wells of The Peoples Natural Gas Company in Clarion and Jefferson Counties. Note here that the initial rock pressure was not as large, but that the rate of decline has not been as great; that is, the slope of the curve on either well is not nearly as steep as has been on some of the other wells.

On page 23, we have rock pressure decline shown on three wells of the Peoples Natural Gas Company in Greene County. There the rock pressure decline has been more marked than in Clarion and Jefferson Counties.

On page 24, we have the rock pressure decline of typical wells of the United Gas Company in Potter and Venango Counties. On page 25, similar curves of the same company in McKean County. On page 26, similar curves of the same company in Clarion, Warren and Butler Counties; and on page 27, similar curves of the Pennsylvania Gas Company in Elk County. There is one difference, however, in the general rate of decline in these, too, in that the rate of decline of these wells in Elk County has not been as great as the wells in some of the other counties.

On page 28, we have the rock pressure decline of three typical wells in Elk County for the Pennsylvania Gas Company. By this combination of three, the rate of decline is practically typical. And on page 29, we have the rock pressure decline of three wells of the Pennsylvania Gas Company in McKean County; and on page 30, the rock pressure decline of three typical wells,—in three other wells in McKean County.

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You will note that in all of these cases, on these records, the name of the sand is given adjacent to the curve or to the well number, so that you can easily identify the sand relationship. The rock pressure decline of three wells in Warren County, belonging to the Pennsylvania Gas Company, is shown on page 31. These are older wells, but have all had a very marked decline.

This finishes the available data on the relationship of rock pressure decline, and turning to page 32, we have a relationship that answers the question as to why there has been so much trouble with natural gas service.

On this diagram, on page 32, we have platted the increase in the number of domestic consumers served by the Hope Natural Gas Company, and the simultaneous decrease in average open flow of new wells drilled during a part of the same period. You will note that the decrease in open flow capacity is even much more marked than the increase in number of consumers. The combination of the two, of course working in opposite directions, has had the immediate practical effect of making the demand for natural gas greater than the available supply.

The decline in average open flow of new wells of the United Natural Gas Company is shown on page 33. This, of course, emphasizes the fact that the new wells that have been drilled in within the last few years have a very much smaller capacity than the older wells,—and for this reason, of course, a given amount of expenditure for drilling wells, will produce a relatively very much smaller volume of available gas.

On page 34, we have the same relationship of declining average open flow of new wells of the Pennsylvania Gas Company. You will note that, first, there was a remarkable decline, and then an increase, and then a marked decline again.

On page 35, we have the average open flow and decline of the Potter Gas Company. In this particular illustration, the number of wells averaged to secure the average plotted product are shown by the small figures adjacent to the heavy black line.

The decline in average open flow of the new wells—of the producing wells drilled by The Peoples Natural Gas Company, is shown on page 36., and the decline in the average flow of the producing wells, of the Potter Gas Company is shown on page 37. There may be some confusion between these two illustrations, and I simply make this distinction: The illustrations on pages 34 and 35, you will note the titles refer to new wells. The illustrations on pages 36 and 37 refer to producing wells, which have been drilled in for a number of years. Referring to the Potter Gas Company's data, on page 37, the number of producing wells that were averaged to secure the average results plotted is shown by the small figures adjacent to

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the heavy black line. That is, in 1914, they averaged the open-flow capacity of 542 wells to get the particular figure for plotting that curve.

On page 38 we have a comparison that shows a general declining situation, namely, the average annual production per well of the Hope Natural Gas Company. On page 39, we have a relationship that shows the change in the number of acres of natural gas land reserved for future service for each domestic consumer. A great many people do not appreciate that for a large company like the Peoples Natural Gas Company, for instance, several acres of land are required for each individual consumer, in order to enable the company to render satisfactory service at the present, and continuous service for the future. This acreage relationship per domestic consumer of the Hope Natural Gas Company is shown on page 40. That shows, for instance, that in 1910 they had approximately three acres of each domestic consumer, and that has dropped down so that at the present time they have only about two-thirds of two acres for each domestic consumer.

Similar data for the United Natural Gas Company is shown on page 41. Here the company in 1912 had about 3.8 acres for each domestic consumer, and this has dropped down so that they have about 2.6 acres for each domestic consumer at the present time. The decline in number of acres of natural gas land owned per domestic consumer of the Pennsylvania Gas Company, is shown on page 42. Here the acreage declined practically at the same rate as for the preceding company.

On page 43 we have the acreage relationship of The Peoples Natural Gas Company. Here we have a slightly increased number of acres per producing well over what they had in 1911. Similar data for the Hope Natural Gas Company is given on page 44. Here there has been a marked decrease. That is, this company in 1910 had 750 acres for each producing well, and this declined so that at the end of 1917 it was down to about 355 acres per producing well.

Similar data for the United Natural Gas Company is shown on page 45. This shows a decline in 1912 of 210 acres per well, and about 175 acres per well in 1917. A similar curve for the Pennsylvania is shown on page 48. Here the acreage per well has declined from 430 acres per well to about 310 acres per well in 1917. Simultaneous with this decrease in reserve acreage, due to the fact that there have been such marked increased demands for natural gas, a number of the companies have been removing the gas faster each year, therefore greatly depleting the available supply for future service. That is, since there is no regeneration and only a fixed amount of gas in the ground which can be removed, if each year

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you are constantly increasing the amount you are taking out per available acre, it makes it very plain to be seen that you are very greatly hastening the day when you will not have any to take out.

That shows exactly what has happened, as far as the Hope Natural Gas Company's property is concerned, from 1910 to 1917. That is, in 1910, they took out an average of about 47,000 feet of gas per acre per annum, and that has been increased 50 per cent. by the end of 1917.

This same relationship for the Peoples Natural Gas Company is shown on page 48. Here there also has been a marked increase in the rate of gas removal. A similar relationship for the United Natural Gas Company is shown on page 49. This also shows a marked increase in the rate of removal. For the Pennsylvania Gas Company we have a similar relationship, shown on page 50. Here the rate of removal was practically constant until the end of 1916, when it increased practically double in one year. The increase in number of domestic consumers served by the Peoples Natural Gas Company is shown on page 51.

Now, bear in mind that in considering this marked increase—and it was a continual growth, 1911 to 1917, therefore making increased demands for service—that you have had the simultaneous, constantly declining condition as far as all of the phases of the natural gas resource end of the business are concerned.

On page 52, we have a relationship showing the number of domestic consumers that can be served by each well, for the Hope Natural Gas Company. For instance, in 1910, they were able to serve 250 consumers from each well. This dropped down so that only 170 could be served from each well in 1917. This change is due to two factors. In the first place, the gas demands for consumers is on the increase. That is, as a general proposition, consumers are demanding more gas now than they did a number of years ago. Simultaneous to that increased demand, you have had this decreased available supply of capacity, the two working in opposite directions bringing about the conditions shown on page 52.

On page 53 you have similar data for the Pennsylvania Gas Company. Here there has been only a relatively small change in 1911 to 1917, although the change has been on the decline. On the whole, I made the statement that the demands for the domestic consumer have been on the increase. What this increase has been for a number of years, for the Hope Natural Gas Company, in terms of thousand cubic feet of natural gas for the domestic consumer per annum, is shown on page 54. For instance, in 1910, the average consumption of each domestic consumer was 110,000, and in 1917, it was about 154,000.

COMMISSONER RILLING: How do you account for that increase, Mr. Wyer?

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MR. WYER: Two reasons: In the first place, having been educated as to the advantages of gas, and then secondly the general fuel shortage. That is especially true for the increase in 1916 and 1917.

The average of the annual consumption in thousand cubic feet for domestic consumer of the Peoples Natural Gas Company, is shown on page 55. Here there also has been an increase as far as the total range of time is concerned, but the increase has not been as large as some of the other companies.

On page 56 we have a relationship of number of producing wells drilled or purchased and dry holes drilled by the Peoples Natural Gas Company. This shows a marked increase in the number of dry holes drilled in the last two years.

On page 57, we have the increase in brake horse power capacity of the natural gas compressing stations of the Hope Natural Gas Company. Of course, the primary object of the compressor is simply to get the gas to market. However, as the rock pressure declines, it lowers the pressure in the field to such an extent that additional compressors are necessary; and even with the same compressor, as the rock pressure goes down, it lowers the capacity of a given compressor. That has had the immediate practical effect of making a very marked increase in compressor capacity necessary in order to meet the increased demands of the consumers at remote markets, and the simultaneous decreased pressure capacities of the wells.

While we are on this gas compressor question, I would like to emphasize another feature, namely: that from a conservation viewpoint, it is not only desirable to use compressors but that every available foot of gas that is in the ground ought to be gotten out. If it is not gotten out at the time the compressor station is in the vicinity where it can be gotten to market, the gas is forever lost. It is not possible to go back and get it later on. Therefore, the public has a very vital interest in any arrangement or any method of operation that will secure the maximum output from a given gas sand. And in order to bring that about, looking at the problem broadly, from a broad public viewpoint, it is very desirable in many cases to put natural gas wells at less than an atmospheric pressure, for the very simple reason that other wells farther back will have to have a higher pressure, in order to get the gas to the station, and unless when you get to the last stages of the operating field, some of the wells are operated at less than atmospheric pressure, you will not be able to get as much gas out of the field as you can or could by operating the wells close to the station at less than atmospheric pressure.

The increase in natural gas compressing station capacity of the Peoples Natural Gas Company is shown on page 58; for the United Natural Gas Company, on page 59, and for the Pennsylvania Gas Company on page 60.

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Another feature that is frequently lost sight of is that it is necessary to go greater distances, in order to develop more remote natural gas supplies. That reflects itself in the total length of natural gas mains used by some of the larger companies in getting that gas and then hauling it to market. The total length of natural gas mains from year to year, in use, in lineal feet, as an index of increasing length of gas haul of the Hope Natural Gas Company, is shown on page 61. That shows an increase from 1910 of about 11,000,000 to 17,000,000 feet, in 1917. The same relationship is shown for the Peoples Natural Gas Company on page 62. The monthly variation in both domestic and industrial natural gas for the Manufacturers Light and Heat Company is shown on page 63. For those in the room who are not familiar with the operating end of the natural gas plant, I want to emphasize the marked peaks that you get—that is, the marked seasonal peaks that you get—on the domestic load, and that indicates the large capacity that you have to have, in order to take care of that peak load service, and yet, as far as the domestic consumer is concerned, can be used only a relatively very small part of the total time.

The monthly variation in natural gas load of the Peoples Natural Gas Company is shown on page 64. That incidentally also emphasizes the largness of the industrial load and the smallness of the domestic load,—the unshaded area on page 64 representing industrial gas consumption. The relationship of domestic and industrial gas consumption for the Peoples Natural Gas Company is shown on page 65. The shaded area on page 65 represents the domestic consumption.

Before we take up the second part of this paper, I just want to make one or two suggestions there. The statement of course is very frequently made that all industrial gas ought to be eliminated. From a conservation viewpoint, that of course would be very desirable, but from a practical operating viewpoint, under present operating conditions, it is physically impossible; that is, as long as there is competition in the field, it is not possible for any one company to conserve the gas either in the summer or in the winter, if another company is taking the gas out from adjoining or adjacent leases, and for that reason, the matter of elimination of the industrial load is one that has very many more limitations in applications than is ordinarily appreciated.

COMMISSONER RILLING: What would be the effect if competition were eliminated?

MR. WYER: Then the companies could pool and conserve the gas, which, from a public viewpoint, would be very desirable.

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COMMISSONER RILLING What is the effect on the productiveness of a gas well if the industry is not served during the summer and the gas is allowed—or the well is allowed—to be plugged up?

MR. WYER: In general, if the well is in good working order, there would be no injury. There are some exceptions to that, if the gas sand is wet, but as a general proposition that would be feasible. But the first problem there would be, that it would be necessary to eliminate all competition and pool the operations.

MR. L. B. DENNING: What effect would that have on the earnings of the company, Mr. Wyer?

MR. WYER: It would very greatly reduce them, and very greatly increase the cost of gas to the domestic consumer, for this very simple reason, that of the total expenditures of the natural gas companies, about 70 per cent. are fixed charges, which would go on, regardless of whether you sold any gas.

MR. DENNING: Then the elimination of industrial gas would consequently result in a higher price to the domestic consumer?

MR. WYER: Undoubtedly—to any consumer.

JUDGE CESSNA: Can you tell me, Mr. Wyer, what proportion of the natural gas in Pennsylvania is used by the domestic consumer and what proportion is used by the other consumers?

MR. WYER: I can. I will give you the information immediately. In the state of Pennsylvania, 72 per cent. of the natural gas is used in industrial work. That is shown on page 39 of the Smithsonian Bulletin.

JUDGE CESSNA: That has reference to gas consumed in Pennsylvania?

MR. WYER: Seventy-two per cent. of the gas consumed.

JUDGE CESSNA: I asked you what proportion of the gas that is found in Pennsylvania is thus used?

MR. WYER: I would have no way of answering that. That is as to—

JUDGE CESSNA: Well, what do you guess it? less of domestic consumers, than it would be of the other class? Go on with your statement and let that drop for the present.

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MR. WYER: At the present time, the domestic natural gas consumption in Pennsylvania, speaking broadly without reference to any one company, but simply considering the state's total, is approximately 42 per cent. of the state's production of natural gas.

COMMISSIONER RILLING: The general average price received for industrial gas is less than for domestic use, is it not?

MR. WYER: Yes.

COMMISSIONER RILLING: Would you care to state how much, approximately?

MR. WYER: The best estimate I can make, Mr. Riling, to answer your question, is that at the present time the average industrial rate would be about 60 per cent. of the average domestic rate.

COMMISSIONER RILLING: Now, will you go into the detail a little, and explain further what would be the effect if competition were eliminated and all gas were to be used for domestic purposes? How would it affect the companies?

MR. WYER: It would require a complete reorganization of the entire industry. It, of course, could not be done unless the field operations were an absolute monoply. That is, you could not get your public utilities together and operate them on any monopolistic basis, and then allow the United States Steel Corporation, which does not consider itself a public utility, to go in and pick the heart of the territory and operate its wells 365 days in the year for steel making. You would have to control the field to the extent of controlling every single well.

COMMISSIONER RILLING: Supposing that were done, then what?

MR. WYER: Of course, the first thing would be that it would very materially increase the price of natural gas to the ultimate consumer.

COMMISSIONER RILLING: Why?

MR. WYER: Because of the fact that your fixed charges are the large part of your cost, and those would go on, regardless of the volume of gas sold. I might state, for your information, that we expect to work that question out on one property, but I would be unable to answer offhand with a limited preparation just what the final result would be.

COMMISSIONER RILLING: Your thought is that if that were to occur, there would be a much smaller amount of gas sold than there is now?

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MR. WYER: Certainly. In the first place, you would eliminate your industrial gas entirely, which, speaking broadly for the entire United States, for instance, is two-thirds of the total gas. That is, for the entire United States at the present time, for every three cubic feet of gas that are sold, only one goes to the domestic consumers, two going to industrial work. Now, you are eliminating two-thirds of the volume that has carried the fixed charge burden, and shifting the fixed charge burden, which is now distributed over three feet, onto one. Incidentally, you would of course very greatly alter very many of the operating charges.

MR. A. LEO WEIL: Mr. Wyer, what would be the effect upon abandoning the industrial supply in carrying the peak load for the domestic supply? I mean, in the cost of operation.

MR. WYER: Well, for most of the companies, you have to have practically the same equipment that you have now, to meet your peak load demand for the domestic consumer, and for a very large part of the time of the year, that equipment would be idle, and of course during that idle period now that the industrial gas is sold so generally.

MR. KANE: How would you limit the Commissioner's question as to affecting the elimination of competition? Would it not follow that while at the beginning there would be the same amount of overhead charges, as matters progressed that would very soon be offset by the reduction in number of officers and length of competitive lines. There are so many duplication of lines at present. Again, the lack of competition, would it not enable them to eventually get all the gas with a less number of wells and thus reduce costs?

MR. WYER: In general, I would answer yes, to your long involved question. That is, it would bring about most of the features that you have mentioned. Incidentally, it would, of course, disrupt the entire industry, because the industry would have to be reorganized from the bottom up. There is not as much competition as your question might suggest. That is, while there is an enormous amount of competition in the field, there is relatively a very small amount of competition in transmission, and it is only the field end of it that would be eliminated, and that would therefore have only a very limited effect on the entire problem.

MR. GREGORY: Mr. Wyer, your main line consumers, are they a profitable consumer to a gas company?

MR. WYER: They are not.

MR. GREGORY: Please give your reason.

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MR. WYER: In the first place, the connection has to be made under high-pressure conditions, and the leakage under those conditions will always be very much greater. Secondly, the cost of looking after these consumers per consumer is very much greater than the cost per consumer of looking after consumers in distributing plants. Third, in a large number of cases, the main line consumer in the past has been either a free consumer or a consumer getting a lower rate. If he is a free consumer the invariable experience has been that he wastes a large amount of gas, due to the fact that the gas not costing him anything, he considers that the gas is cheaper than matches, and will therefore allow his fires to burn continuously rather than to shut them down or turn them off.

MR. DENNING: Mr. Wyer, is it or is it not true that in every distributing plant there is a very much larger amount of domestic consumers, and the total amount of gas does not pay the cost of operation, for the total conumer charge for that class of consumers?

MR. WYER: As a general proposition, that is true, varying in degree for diffierent communities.

MR. DENNING: Is not it also true that the cost of delivering gas to those consumers who do not pay their proportion of the cost is borne by the consumers who pay for their service in very much larger proportion than by this class of industrial consumers?

MR. WYER: That is true.

MR. DENNING: Then it is also true, is it not, that to eliminate industrial gas there would follow a readjustment of consumers charges in very many directions? Isn't that true?

MR. WYER: You would have to reorganize the operating end of the industry from the ground up, and readjust the entire rate situation.

MR. DENNING: So that in the end that really comes down to this proposition, that if the domestic consumer, who is so much greater in numbers and using so much less volume of gas, desired, as a matter of public policy and as a matter of wise conservatism on his part, to prolong the life of the gas field, and as a corollary to that, requires the elimination of industrial gas, he must voluntarily assume the burden of a higher price for the product that he uses? Is not that correct?

MR. WYER: He has to, because there is no one else to assume it.

MR. JACKSON: How much higher? Is there any way of getting at it?

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MR. WYER: I cannot answer that question accurately, for the reason that I do not have an accurate analysis of a large operating company, such as we expect to have some time in the future. It would be my best judgment, however, that if that were done, natural gas rates would go to the neighborhood of a dollar.

MR. WEYMOUTH: Referring again to the Commissioner's question as to the relation between the domestic and industrial rates, I would like to say that in Northwestern Pennsylvania there is one cent difference at present, or three per cent., between the industrial and domestic rate, and I am told that in the Pittsburgh district the rates are the same now.

MR. WYER: That is true. Any other questions?

MR. H. E. EHLERS: Referring to the charts, pages 43, 44, 45, and along in there, the term is used, "decline in number of acres of natural gas land owned." What is the significance of the "owned"?

MR. WYER: It means the mineral rights. It does not mean the surface rights—that is, a leasehold estate.

MR. EHLERS: Referring to the chart on page 64, which shows the relative consumption of gas for domestic and industrial purposes for the Peoples Natural Gas Company, in that analysis what has been done with the gas that is wholesaled by the Peoples Natural Gas Company to the distributing company, as, for example, at Johnstown?

MR. WYER: My memory is that that is all included in here.

MR. EHLERS: In the domestic?

MR. WYER: Yes; that is, that whatever they would sell as domestic would appear. In other words, that the company and its distributors are considered one operating end of it.

COMMISSIONER RILLING: Mr. Wyer, I think it is conceded now that the desirability of competition has been exploded. At least, the Public Service Commission is trying to educate the public that it is not the proper thing to have, resulting in economic loss, and poor service. Will the same reasons apply to the natural gas business as would apply to other public utilities; and would it be desirable if it could be done, to have all the natural gas in Pennsylvania produced, without competition?

MR. WYER: It would be very desirable, from a public viewpoint.

MR. E. S. TEMPLETON, of Greenville, Penna.: Would that be true, considering that we are getting so much of our gas from West Virginia?

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MR. WYER: Yes, sir.

COMMISSIONER RILLING: If that were true, would it still be advisable, or would it be considered advisable, to do away with the selling of gas for industrial purposes and sell it all for domestic purposes, on account of the peak load?

MR. WYER: My judgment would be that it would not; that it would still be desirable to sell some gas for industrial purposes—that is, in certain communities. That is an economic problem that would be controlled by the condition of the field, the number of the population, and the local market. There can be no argument, of course, but what the industrial gas ought to come off, in order to give the domestic consumer precedence on the service during the peak load period, in the winter time.

COMMISSIONER RILLING: What do you think as to the respective rights, as a social problem, of the domestic consumer to have the gas as compared with the right of the industrial consumer?

MR. WYER: It seems to me it is not debatable. It seems so plain that the domestic consumer should have precedence and that no argument could be put up that ought to be given any consideration. There is a very practical reason for that. For instance, take your smoke problem. The ordinary domestic consumer cannot put in smoke-consuming appliances. He cannot afford to put in stokers to handle his coal, so that he can burn it without making a smoke, or he cannot have appliances for stoking his plant. All of these are entirely feasible and desirable for the industrial consumer. The industrial consumer can put in mechanical means for handling the raw fuel, all of which the domestic consumer can not do; and from a service viewpoint, as a matter of convenience and comfort, it seems to me there can be absolutely no argument that from a broad viewpoint of public interest, the domestic consumer should always be given precedence on service.

MR. E. S. TEMPLETON: Where do you class gas engines?

MR. WYER: As a general proposition, the same as a domestic consumer. The consumption,—that is, the total amount of gas used by gas engines is relatively small and seldom a disturbing factor in the service. And natural gas at the domestic rate is by far the cheapest fuel that you can get for that sort of service. Are there any other questions?

MR. GILSON: What would you say, Mr. Wyer, is an industrial use of gas?

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MR. WYER: Using gas for all steel making operations; all ceramic operations, such as burning brick, burning tile, porcelain; all large heating—that is, heating large buildings; the use of gas under steam boilers. I guess the list could be multiplied almost indefinitely. By domestic consumer I mean the ordinary individual householder or apartment holder.

MR. GILSON: Your statement that a gas engine is practically a domestic user of gas, suggested the question that there might be other uses of gas in industries which followed perhaps the same principle, yet merely classified them as a domestic rather than an industrial user of gas, although paid for, we will say, by manufacturers.Can you you think of any other instances?

MR. WYER: There are a large number of other instances where the gas volume used is small and where it has a very vital bearing on industrial operations, but I can not think of one now that is as important, from an industrial viewpoint, as the gas engine, because if you can not use the gas engine your factory has to shut down; but there are a large number of high grade industries where they use gas —thinking now of japanning ovens and the use of gas irons in tailors' shops, and things like that that are what might be called intensified applications where if they were deprived of the gas for a few hours or a few days it would not have nearly the disorganizing effect on the industry as the loss of power would.

MR. TEMPLETON: I believe the typesetting machine is one of those machines?

MR. WYER: Yes.

MR. TEMPLETON: That burns almost no gas and yet the gas is vitally necessary.

MR. WYER: Yes; but you could use gasoline just as well.

MR. TEMPLETON: You could use gasoline?

MR. WYER: Yes, you could.

MR. GRIFFIN: We use gas in annealing operations; the gas is used for the chemical effect. That is, it is put in the waffles to keep the air out—while the material is cooling.

MR. WYER: What is the chemical effect?

MR. GRIFFIN: To prevent steel from oxidizing. It is the only known material that we have ever found that will do it. Where would that be classified? You will find that several concerns in the Pittsburgh district are doing the same thing.

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MR. WYER: I would say, as a general proposition, under conditions like that, that the value of the service would be such that you would find it cheaper to pay the domestic rate and you would come in on the domestic basis, except at such times as the domestic consumer would have to have the gas during extreme peak loads. For instance, in New York City at the present time there is an enormous amount of manufactured gas used in industrial operations, at practically the same as domestic rates—a gas having only half the heating units that your gas here has. I merely mention that so that if you get down to brass tacks, and appreciate the use of natural gas, there are very many high grade operations where it could be used.

MR. GRIFFIN: You think there would have to be exceptions made in the use of gas in cases like that?

MR. WYER: Oh, certainly. The industrial operation that raises most of the disturbance is the large steam industrial boiler, the large steel plant, and the large ceramic plant.

COMMISSIONER RILLING: How serious would it be if they were deprived of natural gas?

MR. WYER: What are you referring to now?

COMMISSIONER RILLING: I am speaking of the steel plant and brick making plant.

MR. WYER: They can go back to other fuels very easily. Many of them are doing it now.

MR. GILSON: It is true, is it not, that about 70 per cent. or more of the domestic gas, that is, of gas used domestically, is wasted, under our present system of using gas?

MR. WYER: Correct.

MR. GILSON: On the hypothesis that the industrial use of gas was about from two to four per cent. of the total gas consumed in a locality, if that four per cent. were transferred from the industrial use to the commercial use for peak load purposes, 75 per cent. of that four per cent, approximately, would also be wasted under our present system?

MR. WYER: That is true.

MR. GILSON: Assuming that four per cent., if transferred, would save us a net gain of one per cent. of the total amount of gas used in the given community, provided other methods of conservation were not adopted at once?

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MR. WYER: Correct. Or to carry out the suggestion—I see what you are referring to. If in a given community, instead of burning natural gas in the fire-pots of coal furnaces, where you waste 70 per cent. of heat energy in the gas, all of those domestic consumers would put in high grade natural gas furnaces, where you would get an efficiency of 75 per cent. and only a waste of 25—that is, just reverse the operation—and if, in their cooking ranges—and this statement applies to most of the ranges on the market, that 85 per cent. of the heat energy in the gas is wasted—they would simply raise their burners and handle the gas economically, so as to about treble the efficiency of these ranges—if all of our domestic consumers in our distributing plants would make those two changes, very many acute service problems of today would be solved.

MR. MCLEAN: Mr. Wyer, what would it do to your income?

MR. WYER: It would very greatly lower the income of the gas company, and as a matter of practical operation, it will never be made by the consumer until gas costs more than cast iron. As long as gas is cheaper than cast iron for changing the burner on his cook stove, he will take the cheaper of the two. Whenever gas is made worth saving, then it will be saved. Or, as I state in the summary, on page 4, 90 cent gas used efficiently for heating and cooking would produce substantially the same gross income from domestic consumers' sources, and the domestic consumer would expend substantially the same amount of money each year for his gas as he is now doing on 30 cent gas, but only one-third of the amount of gas would be used for doing the work.

MR. DENNING: Would it be necessary for the consumer, with the present appliances, to go to any particular expense to install new or more efficient appliances, or can the present stoves and ranges be adjusted at comparatively nominal expense?

MR. WYER: We are getting a lot of data together at Kansas City, where an extensive survey has been made, by making an examination of every stove in Kansas City, Missouri, and indications are that ordinary gas ranges, in good repair, can be put on an efficiency basis, to at least halve, or in general cut the gas consumption down one-third, at an expenditure not to exceed five dollars per range. My own belief is that if that is handled on a basis of making the most of the changes at the same time, it can be very materially reduced. As far as gas furnaces are concerned, the cost of making the change from burning natural gas in an ordinary coal furnace to burning it in a high grade natural gas furnace would, as a general proposition, spoil the looks of a hundred dollar bill. Any other questions?

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MR. GILSON: Did I understand you, Mr. Wyer, that there is an equity in favor of the domestic user of gas over the industrial, at the peak load period, or in cold weather?

MR. WYER: I think that is not debatable.

MR. GILSON: Which way—yes or no?

MR. WYER: That the domestic consumer should be given precedence over every one else; that is, for instance, as between a house and a gas engine, if you can not keep both going, keep the house going.

MR. GILSON: That might vary, however, with the circumstances and conditions surrounding both the domestic user of gas and the industrial. For instance, there might be a community which was dependent upon the industrial use of gas, which, if prevented, would destroy the industry at that place,

MR. WYER: On the other hand, if your laborer does not get a warm breakfast he is not worth much to the industry.

MR. GILSON: But if you can not pay your laborer, he can not get a warm breakfast, can he?

MR. WYER: But the point you are making is that if it came to a show-down between the two, the industry should get the gas?

MR. GILSON: No; I did not mean to say that. There might be circumstances, for instance, where an industry would have to close down, if it could not get the gas. Now then, that industrial user ought to have the preference over the domestic user, if the latter could use some other fuel for heating and cooking purposes. For the good of the community, the industry ought not to be compelled to close down. Do you subscribe to that doctrine?

MR. WYER: In general, no; for I believe that the smoke problem in a community is a very vital local feature, and that can be solved only by the use of gas, for domestic and economic purposes.

MR. GILSON: Well, as a financial problem and outside of the smoke problem, what would you say?

MR. WYER: I would still be inclined to think that the domestic consumer should be given precedence, as long as there is available gas.

MR. GILSON: Why?

MR. WYER: For the very simple reason that industry can ordinarily handle substitute fuels very much easier than the domestic consumer can. If you will limit your inquiry to such an industry or such an operation where no substitution can be made, then there would be some merit in your case.

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MR. GILSON: I understood I did so.

MR. WYER: That was not clear. Then there would be some merit to your case.

MR. WHITTMER: So I understand you to say that if the gas were all preserved for domestic purposes, the price, in your judgment, would need to go to a dollar a thousand?

MR. WYER: I said it would have to go in the neighborhood of a dollar as the average price.

MR. WHITTMER: On account of the continued overhead costs that can not be eliminated?

MR. WYER: Yes, sir. And do not forget this factor too—and this is, of course, the most troublesome of all—that just as soon as you get about sixty cents you begin cutting down on the volume, and the law of diminishing returns begins to apply. Now, as to where the most economical rate would fall, I would be absolutely unable to state, without a very careful study of a given situation. It might be, at least I think there is a good chance that this would work out, that a lower rate for a smaller consumption, say five thousand, could be made to work out; and then an increase in the schedule for a larger consumption, so as to make the consumer who is responsible for the peak load pay for the increased cost of the service that he was receiving.

MR. WHITTMER: The fact is that even though industrials were not permitted the use of gas, there would still need to be nearly as many wells, as much capacity, and in a general way all overhead costs would be, as I said, nearly as great as is the case in allowing industrials to have gas practically only in the summer time?

MR. WYER: That is true:

MR. WHITTMER: It would not mean a very great reduction in the number of wells.

MR. WYER: It would not.

MR. WHITTMER: The plant itself would remain practically the same?

MR. WYER: The present plant. It would mean very much more economical operation in the future, as far as drilling operations would be concerned. But that would be in the future. You would have the practical immediate present to handle, and that would be the most troublesome feature of all.

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MR. DENNING: Have you ever given any consideration to what might be termed a seasonal preferential rate; that is, a higher rate during the summer, when domestic consumption is low, and a lower price in the winter, when domestic consumption is higher?

MR. WYER: I have.

MR. DENNING: Might I ask what conclusions, if any, you have reached on that particular point?

MR. WYER: I am unable to formulate any definite statement on that point. I have given a great deal of time to it and it seems to me that, as a general proposition, it is largely a local matter; that is, while that would work out very well in one form in one community it would not work out so well in another community, and, therefore, based on a rather extended study of it, I have come to the conclusion that no general statement could be made that would be applicable to natural gas operating conditions generally.

MR. JONES, Coundersport, Pa.: In speaking of preference to be given to gas engines over other industrial uses, how would you classify the use of gas engines by other public utilities, such as water companies and electric light plants? For instance, there are many water plants that are pumping—that have small pumping plants, which could not be very well operated by steam power, that are now operating by small gas engines.

MR. WYER: Why not put in a supply of gasoline and run on that during the peak load period?

MR. JONES: Many of those engines are operated by a man attending to them only once or twice a day. I know of one water plant that has two or three small units which are attended to by one man who can only make a visit to the operating plant say twice a day.

MR. WYER: Then the gas consumption would be so small that shutting the engine off or keeping it on would make very little difference.

MR. GERRY KINCAID, Corry, Pa.: Where the industrial consumption was small, say 10 per cent., wouldn't you say it would be better to give the domestic consumer the benefit of that ten per cent.?

MR. WYER: In case of that, yes.

MR. KINCAID: Would not the general benefit to the community be greater than the appreciable difference to the benefit of the domestic consumer in, say, cases where the industrial consumption was only four per cent.—would it not be a greater benefit to the community to allow the industry to have the benefit of the use of that small percentage rather than to give it to the domestic consumer?

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MR. WYER: That is a large question to answer at arm's length. I appreciate the point you are raising has some merit.

MR. KINCAID. For instance, in the city of Erie and in Corry, where the industrial consumption, I understand is less than four per cent., would the benefit to the domestic consumer be great enough to at any time justify depriving the industrial consumer of the use of gas, as a public good?

MR. WYER: Of course the four per cent. will make very little difference; it is the last straw that breaks the camel's back. It is the distinction between the service that you think is usable and the consumer may think is not usable.

MR. KINCAID: Do you have the data from which the industrial consumption of the Pennsylvania Gas Company can be given?

MR. WYER: No, I have not, but you could, no doubt, get it from the company.

MR. GREGORY: If you have two communities which are using gas furnished by a company, and, for instance, their consumption exceeds the company's supply—largely exceeds its supply—would you divide that consumption between the communities, or would you eliminate one of the communities, both as an economical problem for the gas company and as a conservation measure?

MR. WYER: The question you raise cannot be answered accurately on a broad basis. For instance, to apply that to a concrete situation, namely, Louisville, which is at the extreme end of a transmission line and where they have a manufacturing plant,—it is my judgment that Louisville ought to be one of the first towns to go back to manufactured gas entirely. Where you have two communities rather close together of say approximately the same size, where neither one is fitted for the manufacture of manufactured gas, then the only equitable way would be to ration the gas to the two communities, and in that way limiting the peak load consumption of relatively a few consumers, you would be able to give usable service to all. I might state that, as a practical illustration of that, I talked with the president of the Louisville Company yesterday morning. The rationing system went into effect Saturday. It has affected, as I recall now, less than five per cent. of the total number of consumers, yet because those consumers were peak load consumers, they have been able to give very good service to all of the consumers, except that this very small percentage did not get as much as they wanted: and it is the first time in several years that they have been able to give good service to a large percentage of the people in extremely cold weather.

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As a general proposition, for those towns that are farthest away from the field and large enough for the operation of a manufactured gas plant, that is, the towns that are at the end of transmission lines —from a public viewpoint—from an economic viewpoint it will be in general preferable to go back to straight manufactured gas rather than to attempt to serve mixed gas, with of course individual exceptions due to peculiar local conditions.

COMMISSIONER RILLING: I think we will ask Mr. Wyer to finish his address now, and then we will interrogate him, if we have any time left.

MR. WYER: Mr. Chairman, we will now take up the second part of the report, and, beginning with page 66, it is not ordinarily appreciated that any manufactured gas that could be made commercially at the present time would have only about one-half the heating value of the natural gas that is supplied. That is, natural gas is worth twice any manufactured gas that can be made. The average price of the new rate schedules that have been put in effect here through the central states in the last two years, the manufactured gas is about $1.25; $2.50 natural gas would be just the same price and the same cost to the consumer, if used in an appliance of the same efficiency.

In Section 6, on page 66, is a relationship that shows the cost between natural gas at a dollar, soft coal at $6.50, 27 cent gasoline, 3 cent electricity and 15 cent coal oil. You will note that even the dollar natural gas, if used with short flame, is by far the cheapest fuel in that list.

One feature covered in Section 7 is one that has already been touched upon in the discussion, namely, that the industry is in a transition state. The mutuality of interest is discussed on page 67, and brings out the feature that this whole natural gas problem is one in which the public, the domestic consumer, and the companies have a joint interest. If some arrangements practical in their character, so that they can be operated, can be worked out, so that the period of natural gas operation can be extended, it will very greatly delay, or it will delay, the day that the consumer will have to go back to the inferior gas, and it will therefore give the consumer more for his money in the interim and from the gas companies' viewpoint, it will enable them to operate under more satisfactory operating conditions. Therefore, the general statement can be made that if rational conservation methods are applied, they are of just as much interest to the consumer as they are to the company itself, and that the two must handle the problem hand in hand.

In Section 9, there is a brief discussion as to what the term "cost" includes. Item "b," at the top of page 68, is the one that is so fre-

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quently ignored, and is the one that will cause more trouble in the future than any one of the other two. Summarizing the natural gas service features for the future, we have, first, that the gasoline in the natural gas should be removed. That is, the removal of the gasoline dries the gas and improves the quality of the service to the consumer. The reasons for this are outlined in detail on page 25 of the attached Smithsonian Bulletin.

In connection with the removal of the gas from the ground, it will be desirable to not only use more compressors but to operate existing compressors at lower pressures. In order to bring about the conservation, it will be desirable to have a pooling of field operations. In order to get a check on plant operating conditions, it is absolutely necessary to use measuring appliances from the field clear in to the domestic consumer. That is, the gas should be measured in the field, measured as it comes out of the compressing station, measured into the distributing plants, so that you have a constant check on your field losses, main line losses and distributing line losses. I have checked a large number of plants and some of the data that we have collected are very surprising. One company, for instance, is operating its entire system with a total loss, between the loss in the field and the ultimate consumer, of not to exceed ten per cent. A group of companies where we have checked distributing plants have losses as high as 70 per cent. in the distributing plants. That is, in one instance 70 per cent. of the gas delivered at the gates of the town was wasted.

That, of course, is not a typical situation, but taking the average of forty-one plants that were covered in that investigation, which investigation was made for the Fuel Administration, we found that the average was about forty per cent. Therefore, the installation and correct interpretation of measuring data is of the utmost importance, if you want to find out what the condition of the plant is; and unless the plant is in workable condition, there can be no adequate conservation.

Another feature that has not been recognized in the past is the electrolysis of underground pipe in distributing plants. The illustration in plate 6 of the Smithsonian Bulletin is an interesting exhibit of one upon gas pipe, in one distributing plant. (The plate is at the back of the Smithsonian Bulletin.) Not only is there a large waste of gas through the holes in these pipes, but you have the property in like hazard, due to the danger and liability of gas explosion.

Another feature that will be very desirable in the future is to lower the distributing pressures. By lowering the pressures in many distributing plants, you can not only cut down the leakage in the distributing plants, but bring about more equitable distribution as far as the consumer is concerned.

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The next feature is that the gas must be used efficiently. That is, you cannot have conservation and continue to burn natural gas in the ordinary typical natural gas range, and waste 85 per cent. of the heat energy in that gas; or to burn natural gas in the fire-pot of an old-fashioned coal furnace, and waste 75 per cent. of the gas. If you are going to have conservation, you will have to teach the consumer how to use the gas efficiently for cooking and how to use the gas efficiently for heating operatings. Now, in my judgment, there is only one thing that will do that. That is, the features covered in section "h" on page 69. That is, the gas must be made worth saving. As to what that yardstick is for any particular situation, of course, is a matter for judicial determination; but I am very sure, and it is based on a large number of observations, that there can never be effective conservation until there is an adequate price.

Some of the features that the companies must cope with in the future are illustrated in graphic form, beginning on page 70. For instance, on page 70 we have the increase in annual average cost per domestic consumer of operating compressing stations, of the Hope Natural Gas Company. That increase is brought about, first, by the increase in labor; second, the increase in supplies and other incidental expenses; and, third, in the larger station capacity necessary to handle a given volume of gas.

Similar data for the Peoples Natural Gas Company are shown on page 71, and for the Pennsylvania Gas Company on page 72. The increase in average purchase price of gas purchased by the Hope Natural Gas Company is shown by the heavy black curve on page 73. The lower curve shown by the dotted line indicates the volume of gas purchased. You will note here that although the price has practically doubled since 1910, the volume purchased has remained practically constant. The average purchase price of gas for the Peoples Natural Gas Company is shown on page 74. On page 75, we have the increase in cost per million cubic feet of open-flow capacity of new wells drilled by the Hope Natural Gas Company. This is brought about by two factors. First, drilling operations are much more expensive than they were several years ago. Second, the amount of gas obtained in a well, as shown on the previous charts, is very much less. These two factors working in oppositie directions, have brought about the increased cost situation shown on page 75. Similar data for the Peoples Natural Gas Company is shown on page 76.

The increase in annual well operating costs of the Hope Natural Gas Company is shown on page 77. The increase in taxes of the Hope Natural Gas Company is shown on page 78. It may not be amiss to re-emphasize the fact that the public does not appreciate that in the last analysis all forms of income and excessive taxes are

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paid by the ultimate consumer anyhow, and that therefore the very marked increase in taxation has the immediate practical effect of increasing the cost of the service to the ultimate consumer.

The tax increase for the Peoples Natural Gas Company is shown on page 79, and for the United Natural Gas Company on page 80. On page 81, we have the increase in taxes for each domestic consumer of the Peoples Natural Gas Company.

MR. COLEMAN J. JOYCE: If the rates are not raised, how are the taxes distributed to the ultimate consumer?

MR. WYER: Ultimately it will, I do not mean that raising the taxes this year makes the consumer pay the tax this year, but in a period of years, all forms of excessive taxation are paid by the ultimate consumer, whether it is on the public service consumer or on a package of cigarettes, in the last analysis the public pays the freight.

On page 82, we have the relationship of property tax, income tax and average domestic rates of the Manufacturers' Light & Heat Company.

Now, beginning on page 83, we have a graphical comparison of several commodity prices, the one on page 83 being metals and metal products and domestic natural gas rates of the Hope Natural Gas Company. That is, in this period of five years gas rates have increased one per cent. The maximum increase in metal products during the same period was 158 per cent. On page 84, we have the same comparison for foodstuffs; on page 85, the same comparison for farm products, and on page 86, the same comparison for clothing. Then beginning on page 87, a similar comparison of the Peoples Natural Gas Company, comparing the rates, first, with metals and metal products, on page 88, with foodstuffs, on page 89, with farm products, and on page 90, with clothing. Then beginning on page 91, a similar comparison with the Manufacturers Light & Heat Company, making the same comparisons with the four commodities, is shown.

Now, if there are any further questions that I can answer on any phase of the natural gas industry, I will be very glad to do so, if I can.

COMMISSIONER RILLING: Gentlemen, this is your opportunity to ask Mr. Wyer questions, which we hope you will avail yourselves of.

MR. GILSON: Mr. Wyer, the analysis assumed in regard to the increased cost of natural gas, or other, the increase in price of natural gas, in order to render it a motive to save, would leave out of consideration as the principle adopted by the majority of the utility commissions, that the price or rate of service is dependent upon a fair return upon an actual value, would it not?

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MR. WYER: No, because you will get a very much lower rate; you will get a very much lower income because of your decreased consumption.

MR. GILSON: You have, we will say, increased the price of gas. Now, that case is a comparative commodity; it perhaps has more value, we will say, than coal. Does not that overlook the principles upon which the commissions have fixed rates in the past?

MR. WYER: It does to a certain extent, but even then, if you were in a rate making calculation, if you had one of two alternatives, figuring on a certain income to keep the property going, with a thirty cent rate, selling a certain volume of gas, or getting that same income, as far as the company is concerned, that is, substantially the same; but with one-third of the gas, because the rate would be three times as large, the public would be benefited by the higher rate, because by so increasing the rate you would very materially lengthen the life of the gas supply, although the gross income to the company would not be very greatly altered.

MR. GILSON: Then as I understand you, it would be a departure from the principle of rate making in the past?

MR. WYER: Yes. I want to bring this out: The whole natural gas industry is a departure from all other public utility problems. It is not comparable.

MR. GILSON: That is what we are trying to get at today, the distinction between natural gas and other utilities.

MR. WYER: Yes.

MR. GILSON: Isn't it also true that these high priced curves showing the increased prices reflect an increase in the raw material in most cases? For instance in clothing and other items which your curves show, the raw material has advanced in price in the year 1917 or 1918, while natural gas is in the ground and the increased cost is confined to operation and distribution, and so on?

MR. WYER: But in reducing that gas to possession, you have to utilize a great deal of raw material to get the gas within your grasp.

MR. GILSON: That is true, but is there not this distinction,—that the raw material in the gas field has not increased in price, whereas the raw material in the hands of the manufacturer has increased in price?

MR. WYER: No, I do not think that is true, because there is no

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ownership in the gas until it is reduced to possession, and when it is reduced to possession, you have spent a lot of money for both material and labor.

MR. GILSON: Now, are not we confusing price with value?

MR. WYER: Well, there is that possibility, but as a practical proposition, fundamentally there is no ownership until the gas is reduced to possession. Now, gas that is reduced to possession now costs you more per million feet than it did five years ago, due in a large extent to the fact that raw material entering into all the various steps to reduce it to possession has very greatly increased.

MR. GILSON: That is really an operating expense, although you cannot say that you have got the gas in hand until you have bestowed upon that gas certain operating expenses; is not that it?

MR. WYER: That is it, exactly.

MR. GILSON: But if we consider as raw material the gas in the ground, then the question I asked you would probably be true, wouldn't it?

MR. WYER: Yes.

MR. JOYCE: To amplify Mr. Gilson's question a little further, wouldn't it be proper, in order to properly interpret these charts, to have some information as to what proportion of the price is expended by the industry, whether gas or clothing, for raw material, and what proportion of the price—the price obtained from the consumer—is profit?

MR. WYER: Certainly.

MR. JOYCE: I have in mind there that the thing that the gas company sells—gas—comes to it from the ground, and whatever cost is put on it is operating cost. The thing that the clothing manufacturer sells, he must spend a very great proportion of the price that he gets, for the raw material, and that element should be at least known before you can read these tables intelligently.

MR. WYER: Well, you are making one distinction there that is not quite fair, I think, for instance, and that is the popular misuse of the word "natural." Now, natural gas is no more "natural" than the wool that enters into the clothing. Just because the sheep may grow and because it may grow wild—if we may carry out that comparison—does not mean that some one has not expended money. For the same reason, even though the natural gas was made by nature it is not available until some one has spent money in making it available to some remote consumer.

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MR. JOYCE: Well, now, the money that the gas company spends in that direction would be what they pay to the landowner for the right to take the gas from the ground—and that has not changed, has it?

MR. WYER: Well, it has increased quite a little. I can not give you the exact increase, but at the present time about thirteen cents out of every dollar that the public pays goes directly to the farmer.

MR. JOYCE: That is all I have to ask.

MR. TEMPLETON: Do you mean thirteen cents per thousand feet?

MR. WYER: I may state it in this way Thirteen per cent. of the average gas company's gross income goes direct to the farmer.

MR. TEMPLETON: As royalty or lease, do you mean?

MR. WYER: Either as royalty or as acreage rental. Or state it this way: Out of every one hundred cents contributed by the public, thirteen cents goes direct to the farmer.

MR. JOYCE: Has that rate changed in the last five years.

MR. WYER: Yes, there has been some change, but there has not been nearly as much change in that item as there has been in some others.

MR. JOYCE: It is that item in the gas industry that would compare with what the clothing manufacturer pays for his raw material in his cloth—what you referred to as cost of the well?

MR. WYER: No, it is still not comparable, because that gives you only the right to go after the gas.

MR. JOYCE: But in the getting of the gas you count all the operating charges—which was your answer to Mr. Gilson.

MR. WYER: Certainly.

MR. JOYCE: I think I have all I want on that question, but I would like to ask you another one, and that is as to the disposition in accounting of the rentals on unoperated leases, whether that should be included in what is designated "operating expenses" and therefore goes against the consumer, or whether it should be considered as a charge against income and therefore paid out of the profits of the company.

MR. WYER: Well, it would make no difference at all. It would not go any more against the consumer one way than the other,—the consumer ultimately pays it. The only difference is that if the rental

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is paid as an operating charge it places the financial operations of the company on a more conservative basis; that is, it decreases the capital account.

MR. JOYCE: I am referring now to rental on unoperated leases.

MR. WYER: The answer refers to that.

MR. JOYCE: We will say that in a rate case before a Commission the gas company is permitted a certain value for its property; it is permitted to earn a certain return upon that value?

MR. WYER: Yes.

MR. JOYCE: The elements going to make up the sum total that the company is entitled to collect from the public is made up of that return plus the operating charges?

MR. WYER: Yes, sir.

MR. JOYCE: Now, in considering rentals on unoperated leases if the item is placed in operating charges—

MR. WYER: It would not appear in the capital account. You cannot have it in both.

MR. JOYCE: But it does not appear in the capital account in any event, because there is no value placed upon it?

MR. WYER: If the value is placed on the unoperated acreage, in the valuation making up the total valuation of the company, then it would not come into the operating charge. If it is not included in the value of the property, then it should come in as a straight operating charge. But in the long run it would make no difference in the cost to the public.

MR. JOYCE: I am afraid I have not made myself clear or else I do not understand your answer. We will say that there is no value placed upon these leases, that the company has been at no cost to get the leases, that—

MR. WYER: You are assuming a condition that never exists in practice; there is always some outlay in getting a lease, but proceed, just for the sake of the argument.

MR. JOYCE: Assuming that there is not,—the company is permitted to place in operating expenses the rental on operated leases?

MR. WYER: Yes, sir.

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MR. WYER: No general answer can be given on that. No yardstick can be laid down that you can apply to all cases.

MR. JOYCE: Each case should be judged, you mean, on its own—

MR. WYER: On its own merits. But in all cases the public must in the end pay for all excursions. If the public does not pay for them the excursions will not be made.

MR. JACKSON: Are the tables which are offered on pages 90 and 91, and following pages, showing increases in the cost of clothing, metals, food stuffs and farm products, offered as showing some standard for gas rates in gas proceedings?

MR. WYER: They are not. They are offered merely to answer the question that is frequently raised—that natural gas rates have gone up to a prohibitive price and have gone up faster than any other commodities.

MR. JACKSON: Of course the gas companies do not purchase clothing or farm products, and the actual test would be what they have paid and not if they had paid for the commodities they did not purchase? Of course they have to purchase labor.

MR. WYER: But when they hire the men they puchase these three products—clothing, commodities, and farm products.

MR. JACKSON: But I notice that there is no actual table of cost to the laborer here; wouldn't that be the test?

MR. WYER: That increase has been substantially the same as these increases in commodity prices. I simply did not give that because the report was so long, as it was. I happen to have those figures and can give them to you if you want them.

MR. JACKSON: I would like them.

MR. WYER: I will get them and give them to you.

MR. JACKSON: I observe that the Pennsylvania Gas Company has increased its cost of operating compressor stations from 1911 to 1918, —it is approximately double; and I observe from your table at page 60 that their capacity has approximately trebled.

MR. WYER: Yes.

MR. JACKSON: So the result of that would be actually the diminishing cost of operation per thousand feet of capacity?

MR. WYER: No; per horse power capacity, but not per thousand feet of capacity.

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MR. JACKSON: So that would not be a consideration justifying an increase of rates?

MR. WYER: It would, so far as the total cost is concerned, in affecting the cost of the thousand feet of gas put out, for this simple reason, that although your compressor station capacity in the aggregate has gone up the output of those stations has gone down, due to the fact that the capacity of the station has been lowered—or the station has been lowered—by the constantly declining rock pressure in the field.

MR. JACKSON: I get your point.

MR. WYER: The effect of lowering the rock pressure on a well, on the capacity of the compressing station, is shown in the table on page 29 of the Smithsonian Bulletin.

MR. JACKSON: One thing more: Is it your opinion that in a rate case such as we have pending with the Pennsylvania Gas Company—do you think that consideration should be given to this item that you have mentioned, of increasing the price to a point where people will not waste gas? Do you think that in a practical rate case that would actually be made a basis of the rate?

MR. WYER: It should not be made a basis of the rate but in my judgment, after the Commission have fixed the value of the property, then they are face to face with of course working out a rate schedule which will give a return that will be commensurate with the hazards in the enterprise; and in working out what that particular rate schedule should be, it would be my judgment that the Commission would not be doing its full duty to the public if they did not consider this practical conservation effect that you can get by making gas worth saving; that is, raising the price and thereby cutting down the volume. Now if this Commission after they had fixed the value of the property had that before them—they would find for instance on a ninety cent rate that the volume would be less than on a thirty cent rate; therefore, there would be a certain credit that would come back in the way of decreased production cost, because of the smaller amount of gas that would be carried to the market; and it is not a matter of merely arbitrarily boosting the price and making the consumer shoulder the losses. It is merely a matter of equity in so prorating the interest on the cost as to increase the life of the gas for the longest possible time and in that way following a basic feature of conservation, which is that of the greatest good to the greatest number for the longest time.

MR. JACKSON: Well, after you have fixed your rate—after you have determined the rate which gives the gas company an adequate return on its investment and the value of the property used for public

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service, you think that the Commission should then go further and add to that an additional rate for the purpose of disciplining the public, so to speak?

MR. WYER: No, sir. When they fix the rate they have done that.

MR. JACKSON: So it is all involved in the adequate return?

MR. WYER: Yes, sir.

MR. JACKSON: It would not be an added charge for discipline?

MR. WYER: No, sir! No, sir!

MR. SULLIVAN: From a practical operating standpoint, is it not advisable for a gas company to carry a reserve acreage to provide for a future supply of gas—and as a protection to the public?

MR. WYER: It is not only advisable, but the gas company owes that in fulfilling its public utility obligations to the public.

MR. SULLIVAN: Now, in developing that acreage—any reserve acreage—and I believe that is generally held by gas companies—it is unknown whether or not it will be productive gas; it may or it may not be, but it is to be presumed that the persons selecting that acreage are using the best judgment that they have in obtaining it—but in developing it, is it not advisable to do exploration work in advance of the time that gas is needed, to ascertain whether or not that is productive territory?

MR. WYER: Certainly.

MR. SULLIVAN: Therefore any adequate return on an investment ought to provide sufficient money to provide for exploration operations, ought it not?

MR. WYER: Yes, sir—and if the return does not provide for that, as I stated before, in the long run the explorations will not be made, the gas will not be located, it will therefore not be available and cannot be used by the public.

MR. SULLIVAN: Well, even in developed fields, or what we ordinarily call developed fields, is it not a fact that a great many dry holes are encountered and that you cannot depend on all the wells drilled in those fields as being producing wells?

MR. WYER: That is true; as an average every fourth hole is dry.

MR. SULLIVAN: And therefore on this reserve acreage that is carried by gas companies, it would be necessary to provide a sufficient

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amount of capital, so the companies can extend their operations into the unproductive or undrilled fields, so as to determine whether the gas is there a sufficiently long time in advance of when the gas is actually needed—to provide for the time when the gas is needed.

MR. WYER: That is true, to insure future service.

MR. SULLIVAN: And in considering the rate, is not that one of the things that should be taken into consideration and money provided for that exploration work?

MR. WYER: It should, and I will repeat again, if it is not taken into consideration in the course of a few years the exploration work will lag to such an extent that the new supplies will not be obtained.

MR. GILSON: Is there any relation between your theory of conservation, or the raising of price to effect conservation, and the comparative value of gas and other commodities as a fuel?

MR. WYER: Well, for instance, dollar gas is the cheapest fuel you can get for cooking.

MR. GILSON: I mean, does that fact affect your theory one way or the other, as to the raising of the price in order to effect conservation, or is each one of those principles independent of the other?

MR. WYER: It does affect it to this extent, that you as a matter of practical operation could not raise the rate above the value of the service. The usable rate to the public can never exceed and must usually be below the value of the service to the public. For instance, to state it this way, three dollar natural gas would not conserve natural gas at all.

MR. GILSON: If you will pardon me, we might state it this way: that at the present time we will say that thirty-five cents represents the cost of service of natural gas; that if it is found upon investigation and upon the proper valuation of the property that an increased rate cannot be put into effect, then even upon the theory that the value of the commodity as compared with other heat producing commodities is higher, then the same thing can be accomplished by adopting the theory that conservation of gas is the motive behind the increased rate rather than to get a return on the comparative commodity value of the products?

MR. WYER: Certainly. For instance, to carry out your illustration further,—assuming that you have made your valuation, assuming that on the basis of existing operating conditions the Commission had found that a thirty cent rate would bring an adequate return to the company, on the basis of selling for domestic consumption an

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average of one hundred thousand cubic feet of gas per domestic consumer per annum—just the average for the United States—my point is that instead of allowing that gas to be used at that rate and therefore used very inefficiently by the consumer—because thirty cent gas is cheaper than the cost of changing either cook stoves or heating stoves—and the consumer would continued to use the gas in a wasteful manner—in his range wasting eighty-five per cent. and in his coal furnace wasting seventy-five per cent.—if now the price were put at ninety cents, the volume cut to one-third, the consumer's bill for gas service would be just the same, the gas company's income from this domestic service would be substantially the same. There would be an opportunity there for a small differential in favor of a somewhat lower rate, due to the fact that under those conditions some operating expenses necessary and an integral part of a thirty cent rate on a hundred thousand foot volume basis, would be eliminated with the ninety cent rate and one-third the volume basis.

MR. GILSON: If the conservation which you seek to obtain by the decrease of product were effected in some other way, of course that would relieve the necessity of increasing the price, to that extent—for instance, by a different kind of burner,—by an adaptation of the present means of the consumption of gas—a more economical use.

MR. WYER: Then you would be face to face with this practical problem, assuming for illustration that over night all of the consumers in one town changed their burners on their cooking stoves and changed their heating stoves so as to do the same cooking and heating service on one-third of the gas, and the rate remains the same. By that change you have cut two-thirds off the company's income and taken it away entirely.

MR. GILSON: Very well. Then they have their remedy in showing the actual return from such reduced revenues because of conservation?

MR. WYER: Yes, sir.

MR. GILSON: And seeking a different return upon their investment after that has transpired, have they not?

MR. WYER: Of course the gas man's answer to that has been in the past and will continue to be in the future, to sell all the industrial gas he can at a lower rate for a different period.

MR. GILSON: Which is also under the Commission's regulation?

MR. WYER: Yes, sir.

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MR. WILLIAM HORNE: Do the natural gas companies at this time employ anyone to meet their consumers or show them how to use the gas correctly or advise them of the most economical appliances?

MR. WYER: I think that all of the larger companies have service or new business departments whose function it is to teach the public the correct use of natural gas. The United States Fuel Administration has put out an edition of two hundred thousand copies of a Natural Gas Primer, the principal object of the primer being to teach correct use of natural gas, and a large number of those have been placed in schools in various towns.

MR. HORNE: I have heard your argument relative to saving gas from the fixture, and I have one article in mind along those lines. I am a plumber by trade. A customer had a furnace for using coal for fuel; he found it unpleasant and sent to Pittsburgh for the most modern burner on the market for using natural gas in his coal furnace. A month that I remember his gas bill in that improved fixture, which cost them nearly fifty dollars to install, the gas bill ran thirty-five dollars for heating. His neighbor with just about the same sized house, got our firm to change their heater from coal to natural gas and they made up the burner with drilled holes that went around very closely to the plate, and heated the house for $17.50 the same month. Then the same party that had ordered the improved burner had our firm change that over with a homemade appliance and brought their bill to eighteen dollars—from thirty-five to eighteen—or a saving in the neighborhood of ninety per cent.

MR. WYER: Most of those patented frills on the market are not worth a hill of beans.

MR. JACKSON: Mr. Wyer, the only thing that appears to me is that this principle of conservation is something which you will have difficulty with in the practical enforcement, because it discriminates. It practically punishes the man who is willing to be careful in order to punish the man who is careless. Now, in order to get away from that—is it practicable and has it ever been tried—to adopt a graduated scale of charges, charging perhaps the person who uses it for cooking purposes a given rate, say thirty cents, for example; charging the man who uses it for heating except in extreme weather thirty-five cents, and charging the man who persists in using it in a wasteful manner forty cents; having a graduated scale according to use and graduating it and instead of charging him less for the greater use, charging him more, would it be practicable?

MR. WYER: It would not be feasible to have a rate schedule which would have different rates for different uses, because you would have to have different measurements for the same uses. It is practicable

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and it is my belief that the most equitable way to sell natural gas is to sell a few thousand feet at a given fixed price, with an increasing sliding scale upward, going in increments say of five thousand feet for all amounts above the minimum amount fixed. In that way the consumer that creates and is responsible for the peak load service is made to pay for the cost of that peak load service. There are a number of such rate shcedules in effect.

JUDGE CESSNA: To come back to what we came here for, conservation, I would like to ask the professor this question.

MR. WYER: Not professor.

JUDGE CESSNA: We will call him that.

MR. WYER: No.

JUDGE CESSNA: Can you define the class of industries that could be cut off without a hurt to the interests of the state, or to the companies that are operating the gas companies? For instance, take large boilers and things of that kind. Could you define that class of cases? If you do, I think there could be a remedy provided in law and in fact to meet the conditions.

MR. WYER: It is practically impossible to draw the line in the industries themselves; that is to say, the industries coming in on one side of the line should, and those coming in on the other side of the line should not, due to the practical problem that you always have the twilight zone, and for the other reason that, regardless of what our opinions and regardless of what our theories may be, we are face to face with this very practical problem, that there is not enough gas to go around, and during the peak load period there is not more than enough gas, speaking generally, for the domestic consumer.

JUDGE CESSNA: It seems to me it would be very hard on the industries and very hurtful to the public and the welfare of the state, to cut out any of the industries. Take Pittsburgh, for instance. Why, it would be almost impossible. But at the same time, I would like to see conservation in its broadest, grandest terms, and I believe it can be done under the present Pennsylvania law, that will give us enough gas for fuel for fifty or one hundred years, if it is properly managed. And that will help to do it. It was suggested a minute ago by one of the gentlemen that there should be, and the Supreme Court has said that there cannot be, one charge to the industry for gas furnished and one to the home, and this is the reason, that because this gas is delivered to the parties at the curb, and from that on it is his gas to do with as he pleases. So you struck it in your answer a few moments ago. There can be on that theory and on the

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increased rate a charge to everybody and everyone alike. That is a very interesting question, and I hope something has been accomplished by the meeting here today. There has been an exchange of general ideas that will help this very complicated question.

MR. E. W. PHILLIPS: You spoke a moment ago in regard to making the rate vary as the consumption increases. Now, as a matter of fact, a large part of the domestic consumers are small consumers, and if that is limited to a certain rate of five feet a month or ten thousand feet a month, or anything else, that would not conserve the gas in the cold weather at all, because it would not reach their limit. Now, could not the same thing be accomplished better by having a different rate for all domestic consumers in the winter than would prevail in the summer? For instance, suppose thirty-five cents a thousand is a reasonable basis for gas: suppose that in five months in the winter the price were forty-five cents, and for seven months in the summer it would be twenty-five cents, the presumption being that the people would use about the same percentage of gas in the five winter months, if they used it for cooking and heating as they did in the seven summer months, making it on the average say thirty-five per cent. Now that would be an inducement to the samll consumer to conserve in the cold weather as well as an inducement to the large consumer and make it more equitable. What is your idea on that method of handling it?

MR. WYER: It is my firm conviction that there is no particular inducement to putting in changed heating appliances; that is, to make the changes that would be necessary to make the change on a cook stove, with the rates at thirty and thirty-five cent gas. That is, with thirty-five cent gas, with say five thousand feet limitation per month, the consumer would figure it was cheaper for him to burn that gas in a stove giving him fifteen per cent. efficiency rather than to spend say four or six dollars making such changes in the burners as would treble the efficiency of the stove. We had a very practical illustration of that in Kansas City. A sixty cent rate did not conserve gas, an eighty cent rate did. The dividing line was somewhere between those two points in that particular town. Kansas City is having adequate service for the first time in eight years in cold weather, with eighty cent natural gas. Of course the gas is used only for cooking, hot water heating and lighting, and incidentally heating stoves.

MR. KINCAID: Was that change in conservation made by a change in the appliances that were used by the domestic consumers?

MR. WYER: They are getting ready now in Kansas City to change

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the appliances. The heating appliances, as far as they are used for natural gas, have been changed, the cooking appliances are in process of change now.

MR. KINCAID: How did the eighty cent rate make the change pay, to this time?

MR. WYER: Because it eliminated furnace heating, that is, the indiscriminate use of gas in coal furnaces; but there are people in Kansas City who are using natural gas in high grade hot water heaters and high grade furnaces.

MR. KINCAID: What is the minimum pressure with the present appliances that should be maintained at the meter for the efficient consumption of gas by domestic consumers?

MR. WYER: You cannot answer that question with the premises you have laid down. There can be no efficient utilization of gas, for instance, in present gas ranges having flames two and three-quarter inches long. There can be effective utilization but not efficient. Now, if you mean to change those stoves, raise those burners so as to cut the flames down and get the manufactured gas conditions; that is, get your burner up to the same place you would have with the manufactured gas stove, or use your burner as in a straight manfactured gas stove, then you will get your best results with pressures of from one to two ounces.

MR. KINCAID: But at the present time, with the present appliances, there should be a pressure of from at least two to five ounces to get efficient consumption?

MR. WYER: No. That gives you very inefficient consumption—very inefficient.

MR. KINCAID: Why?

MR. WYER: Because with that long flame cooking operations you get very inefficient operation in combustion conditions.

MR. KINCAID: Don't you get best conditions when your vessel or whatever you are trying to heat is at the peak of the flame?

MR. WYER: Yes, but you are wasting a very large amount of gas in trying to do that. If you have the tip of the flame three inches from the burner it will take approximately three times as much gas to do the same work as if you have the tip of the flame three-quarters of an inch from the burner.

MR. KINCAID: Then if your burner is three inches below the vessel and your gas pressure is lowered so you get one-third pressure

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it takes three times the amount of gas to heat your vessel as it would if you had the peak of your flame against the vessel and the pressure was higher?

MR. WYER: It would not necessahiiy be in that ratio. It would take more gas.

MR. KINCAID: Isn't that the reason for the increased consumption of gas for each individual consumer, as set forth on page 352 in your chart?

MR. WYER: No; because the period of low pressure is relatively a very small proportion of the time for the average small town.

MR. KINCAID: Would not the increased consumption per individual, as shown by your chart, be greater in accordance with the decrease in the amount of pressure with the present appliances?

MR. WYER: Yes.

MR. KINCAID: And the gas company would receive a larger compensation for less efficient heat, the law being the greater the pressure the less the efficiency?

MR. WYER: No; because the time will come when they will not be able to give good service. You get the best results when you get your pressures down so that the flame—I am speaking of cooking operations—when the cock is wide open the flame will just come up so that the extreme non-luminous part of the flame will just touch the vessel, which will be that the luminous cone will be about three-sixteenths of an inch below.

MR. KINCAID: Would not you have the greatest efficiency if you had a stationary cone and the pressure to keep that flame visible and combustible at all times?

MR. WYER: Yes, sir—a condition, however, which is impossible in a natural gas plant for the reasons given on page 48 of the Smithsonian Bulletin, where an anaylsis is given as to why the standards for natural gas must be lower than the standard for manufactured gas. Any other questions?

MR. GILSON: Mr. Gregory gave an illustration between the main line user of gas and the comparatively remote user of gas. Did I understand you to say that it was more expensive to supply the main line user than it was one at some little distance away?

MR. WYER: No. The question was as to whether a main line consumer cost more than a consumer in town, and the answer was that the main line consumer did cost more than a consumer in town.

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MR. TEMPLETON: That is, a consumer on a high pressure main?

MR. WYER: Yes; that is, a consumer getting his service directly from a high pressure main out in the country, the cost of looking after that consumer and his general expense to the company is greater than the cost of the consumer in a distributing plant.

MR. GILSON: I suppose that would be dependent partially upon the distance of the consumer from the producing field?

MR. WYER: Certainly; but these main line consumers are scattered all along the line.

MR. GREGORY: Is that not also on a conservation basis, more expensive?

MR. WYER: Well, the reason I gave before was simply this, that the majority of these main line consumers are either free consumers or—

MR. GREGORY: Leave out the question of the socalled free consumer.

MR. WYER: Well, state it this way. The majority of main line consumers use much more gas than the average domestic consumer in town.

MR. GREGORY: And don't they waste more by breakages happening?

MR. WYER: Certainly. That is all considered in the answer.

MR. GREGORY: And a good many times weighting down the regulators.

MR. WYER: That is sometimes a favorite pastime.

COMMISSIONER RILLING: Anybody wishing to ask Mr. Wyer any further questions? Mr. Wyer, we certainly feel under great obligations to you for your patience this afternoon—

MR. HORNE: What percentage of consumers can read a meter, in your opinion?

MR. WYER: Oh, one-tenth of one per cent.

MR. HORNE: If your answer is correct, and you have heard the order, or most of it, that if the consumer burns over twenty-four thousand feet he should be penalized by having his supply shut off. Do you think that the Public Service Commission has used its good judgment there for the consumer?

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MR. WYER: The whole point is that it does not require any particular amount of gray matter to read a meter, but simply that people have been careless, they have not looked into it, have not familiarized themselves with it; it is only a part of a general education to be required to learn to read a meter, and if the average consumer would learn to read a meter there would be fewer complaints about high gas bills.

MR. TEMPLETON: I think most of the people understood this morning that this limitation of twenty-four thousand feet per month was intended to be general.

MR. WYER: It is not. It is for a particular community.

MR. GILSON: Mr. Wyer, I wonder if you can give us any information as to the comparative price paid by industrial users of gas in Pennsylvania and domestic users?

MR. WYER: I can, as an average right direct from the Geological Survey statistics, and can give it to you for individual companies, but the Geological Survey's statistics of course are not up to date.

MR. GILSON: With the permission of the Commission, may I ask Mr. Gates how the price of industrial gas compares in Pittsburgh with the domestic?

MR. GATES: The price of the industrial gas in Pittsburgh is thirty-five cents net, and that is also the price of the domestic.

COMMISSIONER RILLING: We are going to ask Mr. Weil to say a few words to us before we adjourn.

MR. WEIL: On account of the lateness of the hour I do not believe I have anything to add.

COMMISSONER RILLING: The Public Service Commission works until six o'clock.

MR. WEIL: I do not believe I have anything to add to this discussion, except to congratulate the Commissioner upon the fact that he suggested this conference, and to congratulate the conference upon the fact that we have obtained an immense amount of very valuable information from those who are qualified to give it and from statistical data that I think can be absolutely relied upon.

There is one phase of the question, however, that perhaps I may be pardoned for suggesting, and that is this: natural gas is not found throughout the United States. There are only about ten per cent. of the people of this country who have had its advantages, It has been found, in other words, in a very small area in comparison to the territory of the United States, and yet, as has been stated,

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it is the most valuable fuel, the cheapest fuel, the most convenient in every particular, that has yet been discovered or used anywhere in the world. In other words, we here, and in a few other places, have had this tremendous advantage. When we speak of its efficiency we do not always take into consideration its convenience. We do not give sufficient weight to the fact that it relieves the housewife, it relieves all those connected with the domestic service of that amount of work which all of us as boys remember when upon the farm we had to carry the wood, or when we shoveled the coal and carried the scuttle to help those in the kitchen.

COMMISSONER RILLING: How about taking the ashes out?

MR. WEIL: That was the worst part of it, and I always dodged that. Now then, what have we to say on the subject that the finding of this gas, this mineral deposit in this limited area, places those who find it and those who use it in an entirely different relation from that which exists with reference to the ordinary public utility, the quantity of which can be supplied by the expenditures of thus much money. Have we given that fact a sufficient consideration? Have you given that a sufficient consideration, in connection with the further fact that the supply is fast diminishing, as has been demonstrated, and the demand is fast increasing, as has been shown, and are we justified, is any Public Service Commission justified, in absolutely ignoring the law of supply and demand, in ignoring the economic law that pertains with reference to all commodities?

Now that law of supply and demand does not apply to any other article regulated by a public service commission or handled by a public utility, because you can furnish the supply by expending the money, but here is something that you cannot; it is a mineral, like a diamond, or gold. You may find a certain quantity, and that is the limit. What right have we to say, in this small area of ten per cent. of the United States, or ten per cent. of the people of the United States, to say to them who want this gas and are willing to pay for it, where this supply is limited, as I have stated, and cannot be supplied by the expenditure of any amount of money, that they may not treat it like the diamond or any other luxury? Now we have forgotten here in the gas belt, we have forgotten the fact that the luxury of today and the indulgence of today becomes the absolute necessity and indispensable of tomorrow. We who have become accustomed to the use of natural gas in our homes would not lose that convenience, would not lose that fuel, if we had the money to pay for it, under any circumstances, and we would be willing to pay almost any price for that convenience to ourselves and to our families. Now why should not that be considered when

we are considering the question of the relation of the natural gas company to the public, and why should not the public consider it in its relation with the natural gas company? Now that was just the one suggestion I wanted to make to those who are here assembled, and one other:

We have heard commented upon the question of the pooling of the gas fields and of the necessity in the line of conservation that that should be done, and we all know that the Sherman Act and the Clayton Bill prohibits that at the present time. Now it may be a matter of some information to some of you here to know that there are those connected with our government who, on account of the fact that in order to provide the efficiency that was necessary during the war, our government over-rode and ignored, in its own behalf, all of the principles of the Sherman Act and of the Clayton Bill; everything with relation to consolidation and agreements for the regulation of prices, and we consolidated the railroads, we consolidated the telegraph companies, we consolidated the telephone companies and the express companies, and we operate them as a unit. Why? In the interest of efficiency. And then through our Fuel Administration and through our Food Administration, we regulated directly prices, in the face of the Clayton Act, and we did that on foodstuffs, on iron and steel products, we did that with reference to almost everything that was used, even with reference to minerals and to ores, and so forth, in the interest of efficiency, in order to obtain greater efficiency. And so it has dawned upon many that efficiency is as necessary in times of peace as it is in times of war. And if to attain this efficiency it was necessary that some of the principles of the Sherman Act and the Clayton Bill should be ignored in times of war, the same condition may obtain in time of peace, and there are constructive statesmen, I may say, here today who are now engaged on the devising of an Act of Congress by which there is to be established a National Board, this National Board to have the power to grant to industries, whether individuals or corporations, public utilities or others, the power and the right of consolidation, and the power and the right to regulate prices under certain conditions, leaving the Sherman Act and the Clayton Bill to remain in full force and effect, except where by any order of this Board those particular matters will be regulated, and propaganda will be made very shortly and these matters will be submitted to the public very soon, in order to obtain the support of the people of the United States, in order that such measure may be passed.

Now with an act of that kind upon our statutes, then this long dreamed of and long sought for opportunity of pooling our oil and gas fields, and preventing this reckless and wasteful competition

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in drilling, and offset wells can be legally and properly provided for, and at the same time any improper and excess advantage that would be sought to be taken of such a measure can be prevented, and those who enter into illegal or improper agreements and conspiracies can be punished, but those that are proper in the interest of efficiency can be tolerated and promoted. It seems to me we will take a great step forward when that shall have been accomplished.

We have talked about the gas fields playing out, and about the difficulties we are going to have, and in a word before concluding, I hope that all of the methods of conservation will be observed, but I am going to dare to step across the line of prophecy for just a minute. I do not believe that we here who have had the advantages of the use of natural gas in our houses and our homes, and in certain operations in our factories, are ever going to return to the use of any other fuel. We are going to conserve it some way. We are going to protect ourselves, and I am speaking now not so much of the company as I am of the public, in whose interest it is. We can all remember when the man on horseback carried the mail bag and we were satisfied. The fast mail has come and we cannot go back to the horse. We can remember when our communications were sent by mail. Now we have the telegraph and the telephone, and they are a part of our life. So we could go through countless activities today and realize that what was once satisfactory no more can be, but we must live with the advantages that we have secured. And I am satisfied that through the inventive genius of the mechanical engineer and the chemist there will be found some means by which can be supplemented this supply of natural gas which will be conserved as a mineral, as a precious mineral; as something to be obtained, and to be protected when obtained, and to be used in the manner in which a precious metal is used, and that never will we go back to the old conditions, and it is up to us—it is up to the public just as much as to the companies, and to the companies as much as to the public, and to the public service commissions of this country, to all help along this line of conservation and protection—that we who have been favored by nature will dare, in the ages to come, to look Dame Nature in the face without being ashamed of our profligacy. Thank you.

COMMISSIONER RILLING: We desire to take this opportunity to thank not only Mr. Weil but all the rest of the speakers who have furnished us information today and prepared these addresses. On behalf of the Commission we want to thank them. We feel amply repaid for the effort we made in coming here today and for having

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suggested this conference. I am sure we have been benefited by it very materially and I trust and hope that all who came will be likewise benefited. It is almost five o'clock, and unless there is some other business, the conference will adjourn.

CONFERENCE ADJOURNED.

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PRESENT AND PROSPECTIVE SUPPLY OF NATURAL GAS AVAILABLE IN PENNSYLVANIA

BY

SAMUEL S. WYER
CHIEF NATURAL GAS CONSERVATION
U. S. FUEL ADMINISTRATION

WITH ATTACHED

SMITHSONIAN INSTITUTION BULLETIN NO. 102, PART 7

ON

NATURAL GAS

ITS

PRODUCTION, SERVICE AND CONSERVATION

DECEMBER 28, 1918

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THE PUBLIC SERVICE COMMISSION

OF THE

COMMONWEALTH OF PENNSYLVANIA

Harrisburg, December 19, 1918.

Mr. S. S. Wyer, Chief Natural Gas Conservation,
United States Fuel Administration,
Washington, D. C.

My dear Sir:

I am enclosing a copy of a communication addressed to all the natural gas companies in Pennsylvania, announcing a conference to be held by this Commission in Room 811, City-County Building, Pittsburg, on Wednesday, January 8th, 1919, commencing at 10:00 o'clock in the morning, for the purpose of considering and discussing the supply and conservation of natural gas in Pennsylvania.

Commissioner Rilling has, I believe, previously spoken to you concerning the holding of such a conference and invited you to read a paper on "The Present and Prospective Supply of Natural Gas Available in Pennsylvania." We have therefore taken the liberty of announcing that fact in the notice which we have just issued.

Yours very truly,

A. B. MILLAR,

ABM-F. Secretary.

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December 28, 1918.

The Public Service Commission of Pennsylvania,
Harrisburg, Pennsylvania.

Gentlemen:

In accordance with your letter request of December 19, I am submitting assembly of natural gas data which has been hastily prepared from my office files, and Government sources. The present natural gas situation in Pennsylvania may be summarized as follows:

1. Natural gas is becoming scarce; demands are now greater than the available supply.
2. Forty-three per cent of Pennsylvania's consumption must be imported from other states, primarily from West Virginia.
3. About 11 per cent of Pennsylvania's production is exported to other states.
4. Rock pressure decline has been general and very marked.
5. Volume of producing wells has declined.
6. Volume of new wells now drilled is much lower than that of earlier wells.
7. Marked recent increase in volume of gas removed per acre of natural gas land, thus greatly depleting reserve supplies.
8. Number of acres natural gas land reserved per domestic consumer on decline.
9. Number of acres natural gas land reserved per producing well on decline.
10. Domestic consumers demands for gas service have increased rapidly.
11. Number of domestic consumers has increased rapidly.
12. Large increase in compressing station capacity has been made necessary by rapidly declining rock pressure.
13. For some of the companies there has been a marked increase in "length of haul," because of the necessity of going to outlying fields to supplement the rapidly decreasing supply in the old fields.
14. Seventy-two per cent of the state's consumption is used in industrial work and this is 12 per cent more than the state's entire production.
15. There is no regeneration; when the gas is removed it is gone forever.

The future natural gas situation in Pennsylvania may be summarized as follows:

1. Cost per domestic consumer of operating compressing stations is increasing.

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2. Purchase price of gas in field is increasing.
3. Cost per million cu. ft. of open flow capacity of new wells is increasing.
4. Well operating cost per domestic consumer is increasing.
5. Taxes have been greatly increased.
6. Natural gas rates have increased only a small fraction of the increase in farm products, food, clothing, and metal products.
7. The total amount of gas available is declining rapidly, simultaneously with marked increased costs in production, the two having the immediate effect of greatly increasing the cost per "M" cu. ft. of gas that can be delivered to consumers.
8. Removal of gasoline from natural gas will improve the service to domestic consumers.
9. Compressing stations ought to gradually lower their intake pressure so as to get every available foot of gas out of the ground. To do this, in some cases, it will be desirable to operate certain wells at less than atmospheric pressure.
10. Lower pressures should be used in natural gas distribution.
11. Field operations should be pooled so as to bring about unity of action in matter of pressures and rate of removal.
12. All natural gas produced should be measured in the field, into and out of transmission lines and into distributing plants, so as to have a constant check on the leakage of the gas in transmission from the field to the ultimate consumer.
13. The consumer should use the gas only with efficient appliances. With efficient utilization the yearly cost to the domestic consumer using 90c natural gas would be no more than with the average appliances now in use with 30c gas, due to the fact that efficient utilization would make a given volume of gas give three times as much service.
14. Smaller volumes of gas will be available for the future. However, with the high efficiency utilization—which is possible—the same heating service can be obtained.
15. Gas must be made worth saving; there can be no effective conservation without an adequate price.
16. The carrying on of the natural gas conservation work initiated by the U. S. Fuel Administration would materially prolong the life of the field and delay the ultimately inevitable day when the consumers must go back to more expensive manufactured gas.

Respectfully submitted,

Samuel S Wyer

Chief Natural Gas Conservation
United States Fuel Administration.

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PART II

PROSPECTIVE NATURAL GAS SITUATION

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UNITED STATES GOVERNMENT

NATURAL GAS CONSERVATION

PUBLICATIONS

United States Bureau of Mines

Technical Paper No. 38—Wastes in the production and utilization of natural gas and means for their prevention 29 pages

Technical Paper No. 42—The prevention of waste of oil and gas from flowing wells in California 15 pages

Technical Paper No. 45—Waste of oil and gas in the Mid-Continent fields 57 pages

Technical Paper No. 53—Proposed regulations for the drilling of gas and oil wells with comments thereon 28 pages

Technical Paper No. 66—Mud-laden fluid applied to well drilling 21 pages

Technical Paper No. 68—Drilling wells in Oklahoma by the mud-laden fluid method 27 pages

Technical Paper No. 130—Underground wastes in oil and gas fields and methods of prevention 28 pages

Bulletin No. 65—Oil and gas wells through workable coal beds 101 pages

Bulletin No. 134—The use of mud-laden fluid in oil and gas wells 86 pages

Bulletin No. 163—Methods of shutting off water in oil and gas wells 122 pages

United States Fuel Administration

Use and conservation of natural gas—Especially adapted for use in schools 16 pages

Conservation by correct use of natural gas for cooking 20 pages

Smithsonian Institution—United States National Museum

Bulletin No. 102, Part 7—Natural Gas: Production, Service and Conservation 67 pages

United States Bureau of Standards

Digest of publications of Bureau of Standards on electrolysis of underground structures caused by the disintegrating action of stray electric currents from electric railways 96 pages

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PART I

PRESENT NATURAL GAS SITUATION

Sec. 1—United States Government Natural Gas Conservation Publications

The activities of the United States Government in conserving* natural gas are summarized in the conservation publications listed on page 8.

Sec. 2—Crux of Natural Gas Situation

This is aptly stated by the United States Fuel Administration as follows:

Natural gas is becoming scarce; the demands for natural gas are now greater than the available supply. When the present supplies are exhausted we must go back to the more expensive and inferior manufactured gas. The use of natural gas is not an inalienable right, but a privilege enjoyed by about 10 per cent of our entire population in the United States, and used in a most extravagant and wasteful manner with no regard for the future, and not appreciated until it is gone.**

Sec. 3—Fundamental Principles

Most of the natural gas service problems of today are the direct result of failure to appreciate the underlying engineering and economic principles controlling the natural gas industry. These are discussed in detail in the recent (December, 1918) Bulletin No. 102, Part 7, of the SMITHSONIAN INSTITUTION, Washington, D. C., on "Natural Gas, its Production Service and Conservation"; this Buttetin is included at the back of this report. Had these principles been understood, recognized and followed, the acute natural gas service problems of today would not exist.

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* For comprehensive definition of term "conservation" see attached Smithsonian Bulletin, page 51.

** Use and Conservation of Natural Gas—Especially adapted for use in schools.

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Sec. 4—Status of Natural Gas in Pennsylvania

Pennsylvania's dependence on imported natural gas is shown on page 11. This also shows the smallness of the amount of gas exported from the state, namely about one-fifth of the amount imported. Since all of the domestic gas sold by The Manufacturers Light & Heat Company and The Fayette County Gas Company, in Pennsylvania, comes from The Hope Natural Gas Company, and for the further reason that a large per cent of The Hope Natural Gas Co.'s production in West Virginia is marketed in Pennsylvania, it becomes necessary to discuss the condition of the Hope property in West Virginia in order to properly appreciate the Pennsylvania situation.

Various features pertaining to the condition of the Pennsylvania natural gas supply are shown in graphical form on pages 11 to 94.

A map showing the main natural gas transmission lines and natural gas using towns in Pennsylvania is shown on Plate 8, at the back of the attached Smithsonian Bulletin.

The United Natural Gas Company and The Pennsylvania Gas Company operating in the northwest part of Pennsylvania are not connected for receiving gas from the West Virginia field. The United Natural Gas Company has what might be termed an iron connection with The Peoples Natural Gas Co.'s line from the Clarion field to the south. However, the gas in this line must travel away from the United and Pennsylvania properties and this line could not be used for carrying gas northward without destroying needed service to other communities.

The Potter Gas Company system in the extreme north and eastern part of the state, extending through to Elmira, New York, is entirely separate and distinct from the main net work of pipe lines.

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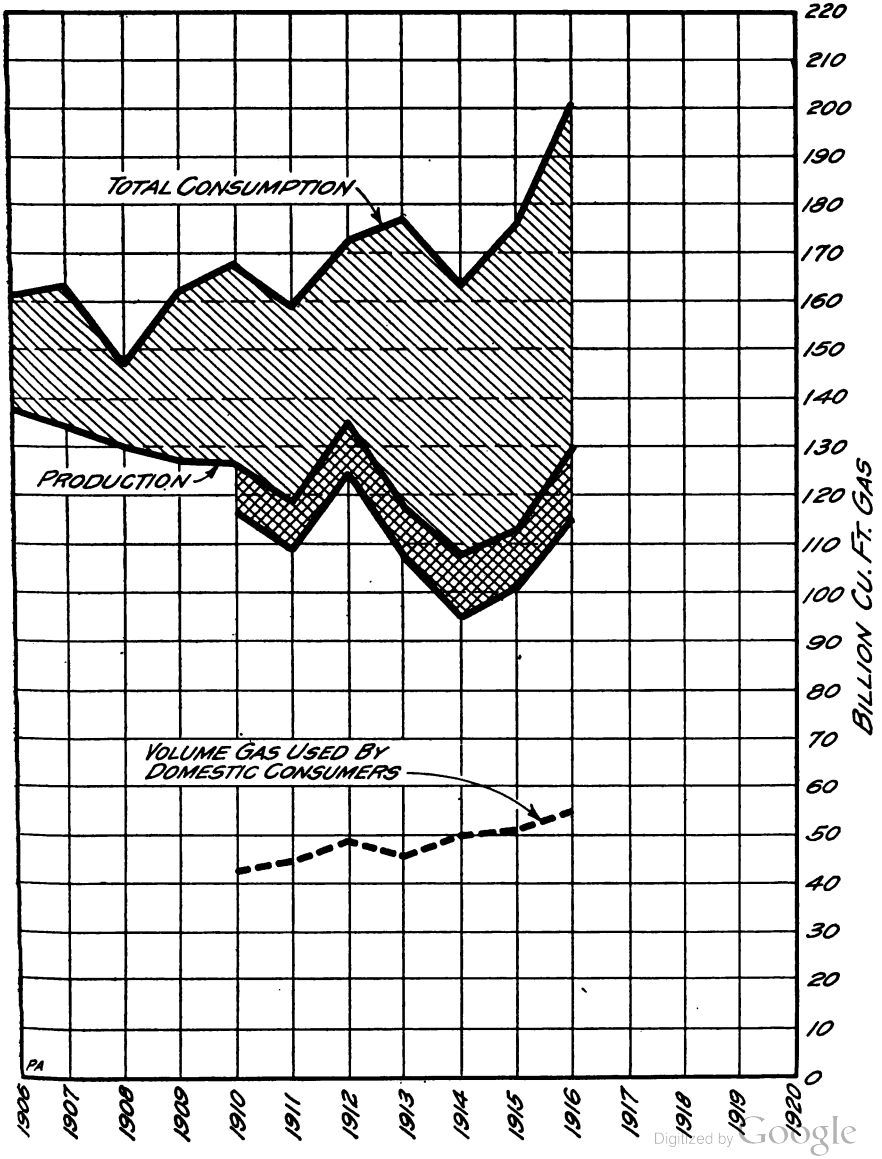
PENNSYLVANIA'S
DEPENDENCE ON IMPORTED NATURAL GAS

The following curves are based on United States Geological Survey statistics. No export data are available prior to 1910, and hence cannot be shown.

The total shaded area represents the volume of gas imported from other states, primarily from West Virginia. The small double shaded area represents the gas exported. Note that the imported gas amounts to considerably more than the domestic consumption.

The interstate relationship of the main natural gas transmission lines is shown on Plate 8 at the back of the attached Smithsonian Bulletin. The data on page 64 of this bulletin are also pertinent.



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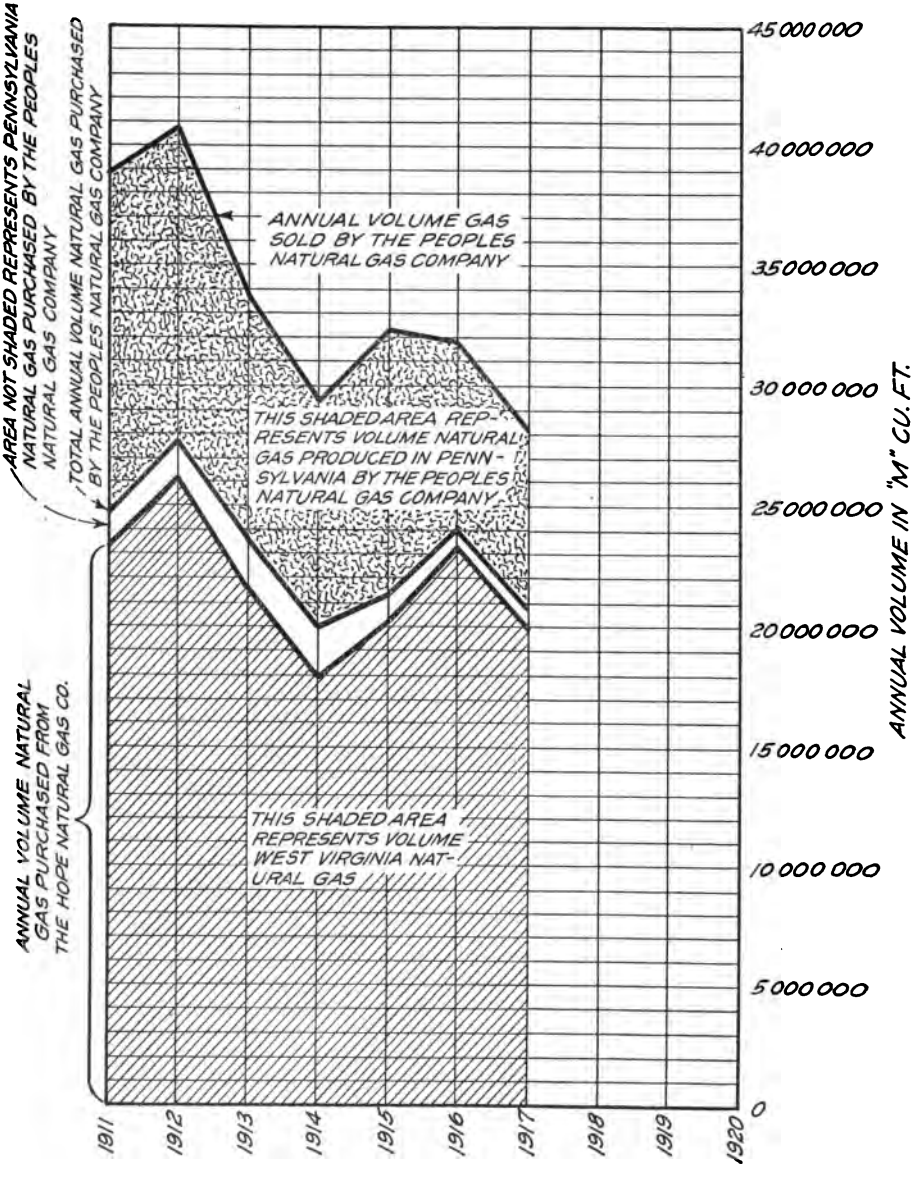
DEPENDENCE OF
THE PEOPLES NATURAL GAS COMPANY
ON
INTERSTATE NATURAL GAS SERVICE
FROM
WEST VIRGINIA



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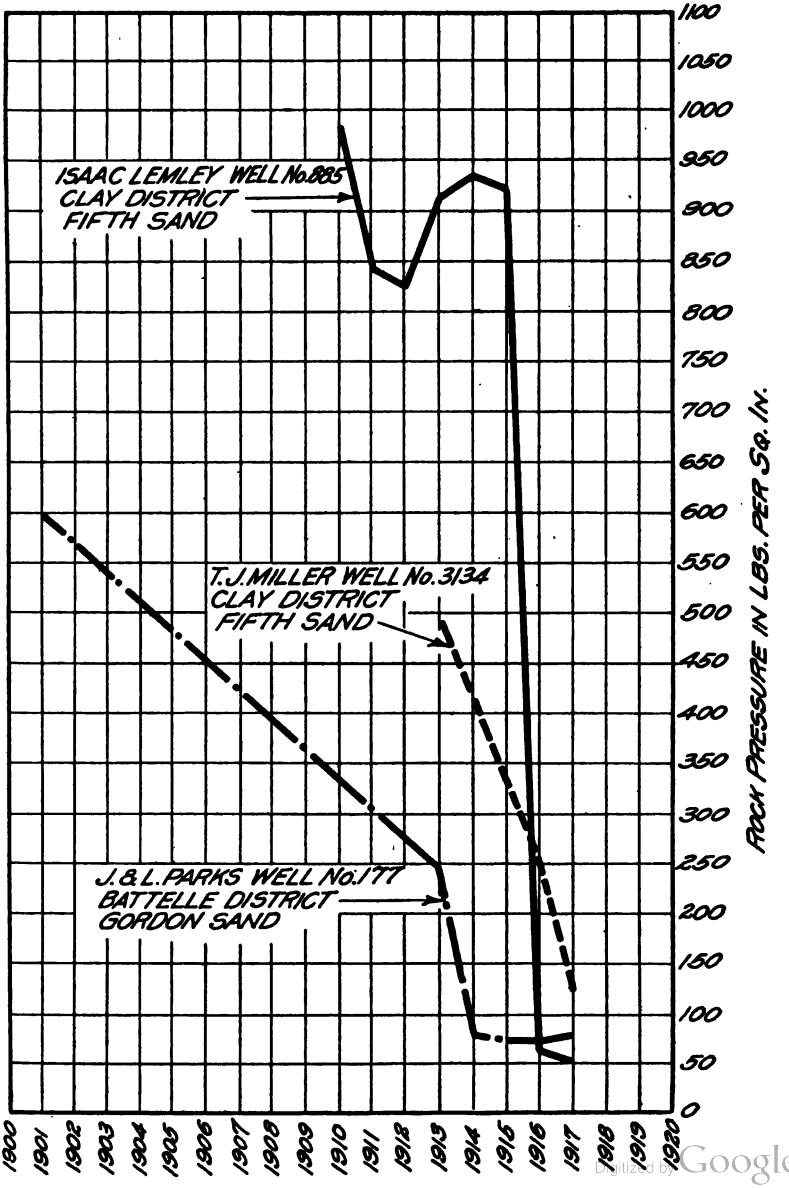
ROCK PRESSURE DECLINE
OF
TYPICAL NATURAL GAS WELLS
OF
THE HOPE NATURAL GAS COMPANY
IN MONONGALIA COUNTY, WEST VIRGINIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.

For general decline of West Virginia natural gas resources, see pages 22 and 23 attached Smithsonian Bulletin.



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OF
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THE HOPE NATURAL GAS COMPANY
IN WETZEL COUNTY, WEST VIRGINIA

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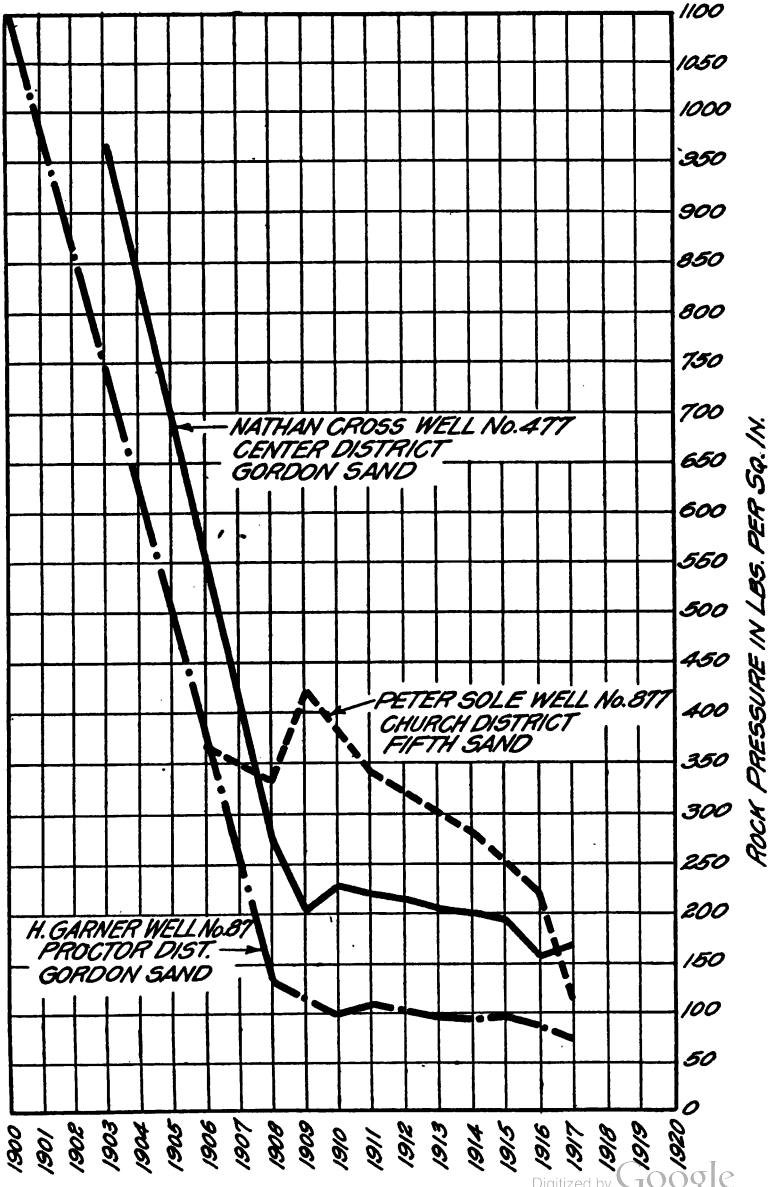
For general decline of West Virginia natural gas resources, see pages 22 and 23 attached Smithsonian Bulletin.



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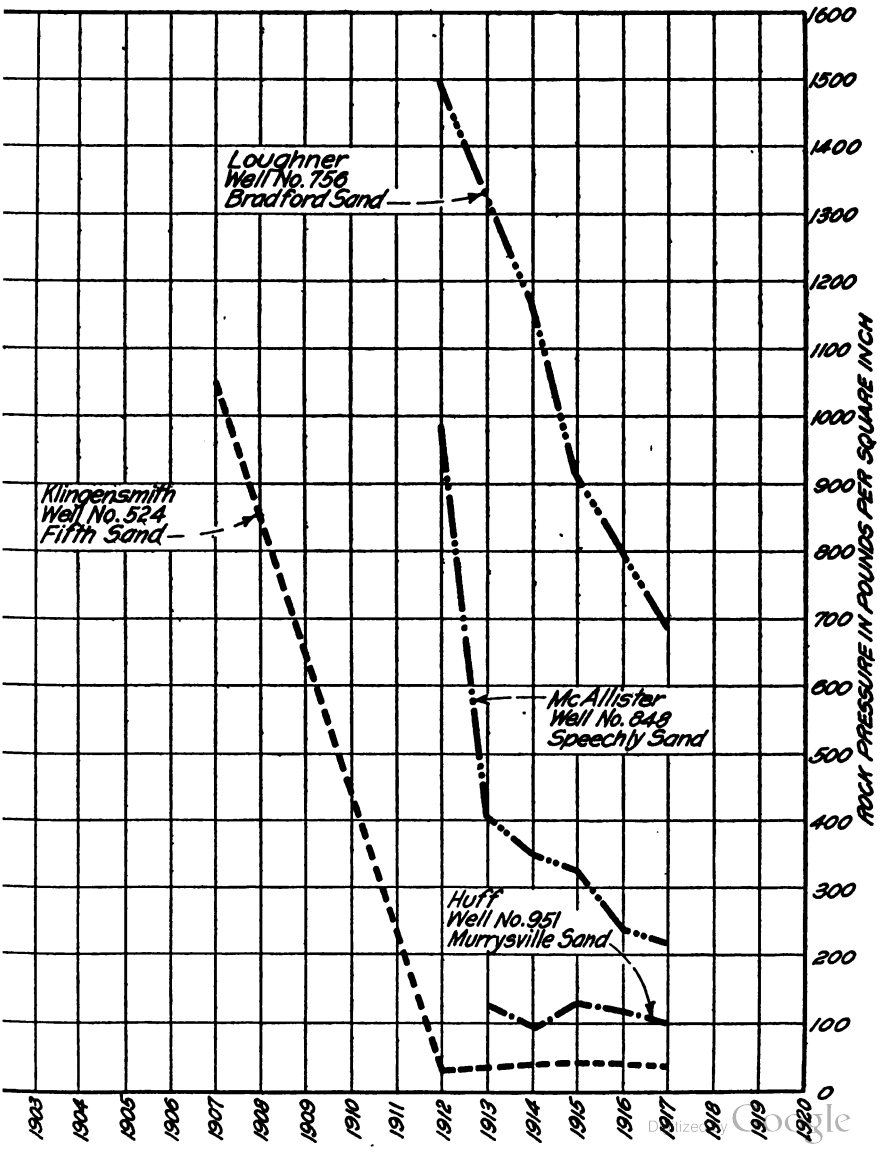
OF
TYPICAL NATURAL GAS WELLS
OF
THE PEOPLES NATURAL GAS COMPANY
IN
WESTMORELAND COUNTY, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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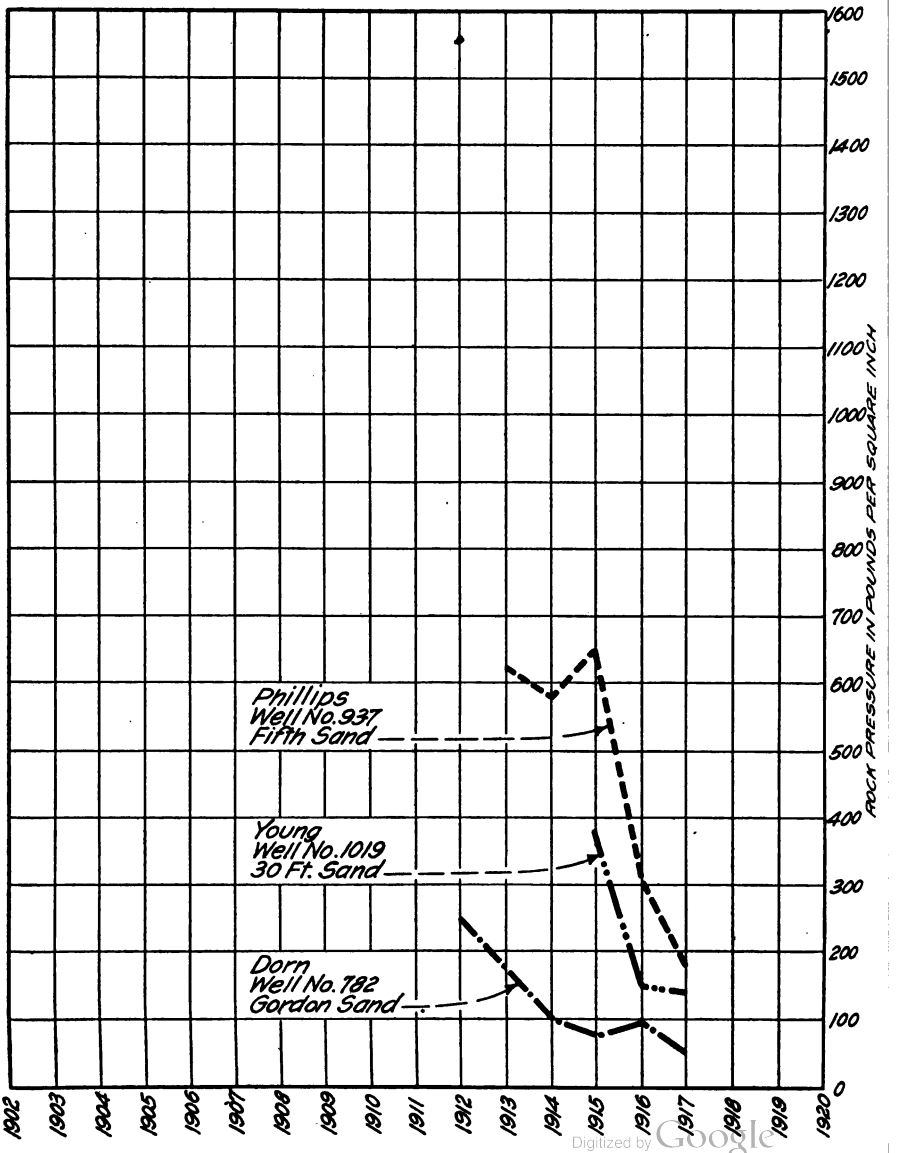
TYPICAL NATURAL GAS WELLS
OF
THE PEOPLES NATURAL GAS COMPANY
IN
ALLEGHENY COUNTY, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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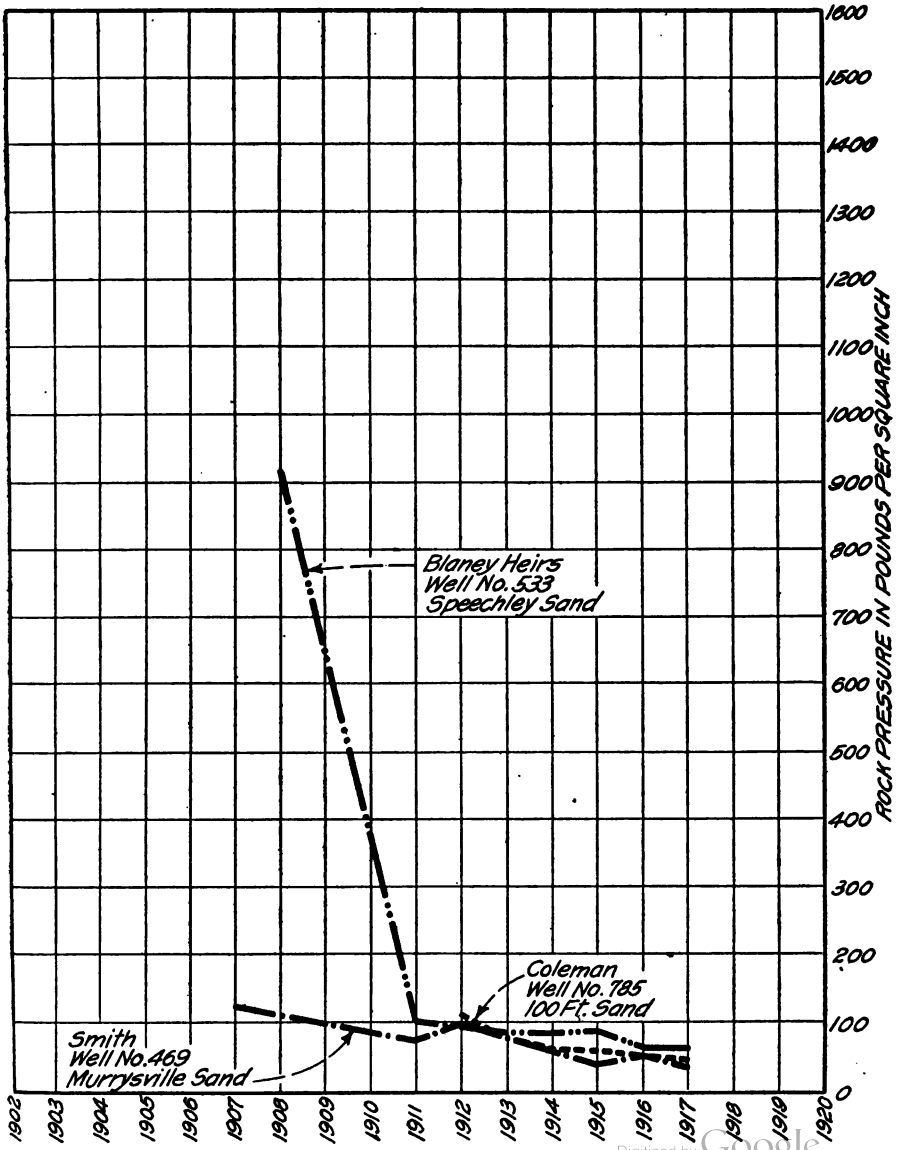
ROCK PRESSURE DECLINE
OF
TYPICAL NATURAL GAS WELLS
OF
THE PEOPLES NATURAL GAS COMPAY
IN
ARMSTRONG COUNTY, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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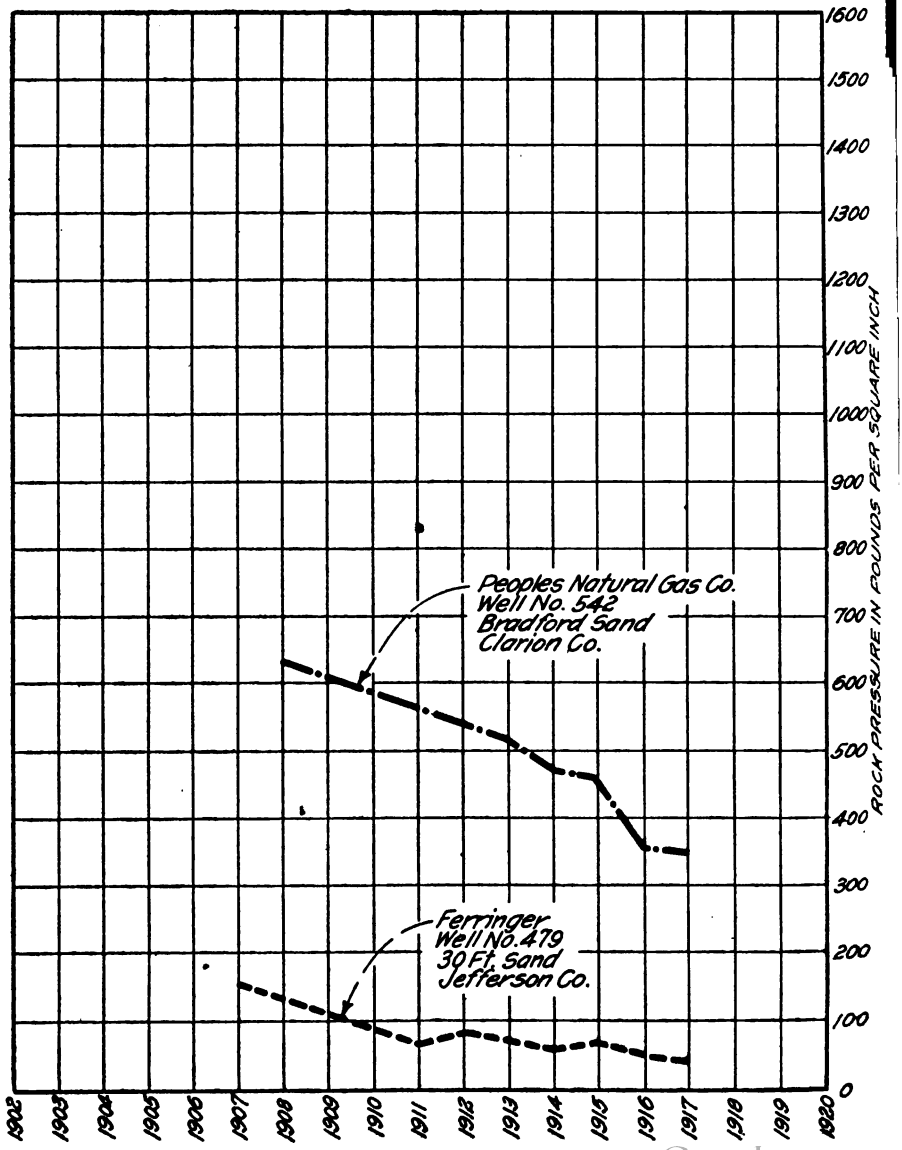
ROCK PRESSURE DECLINE
OF
TYPICAL NATURAL GAS WELLS
OF
THE PEOPLES NATURAL GAS COMPANY
IN
CLARION AND JEFFERSON COUNTIES, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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IN
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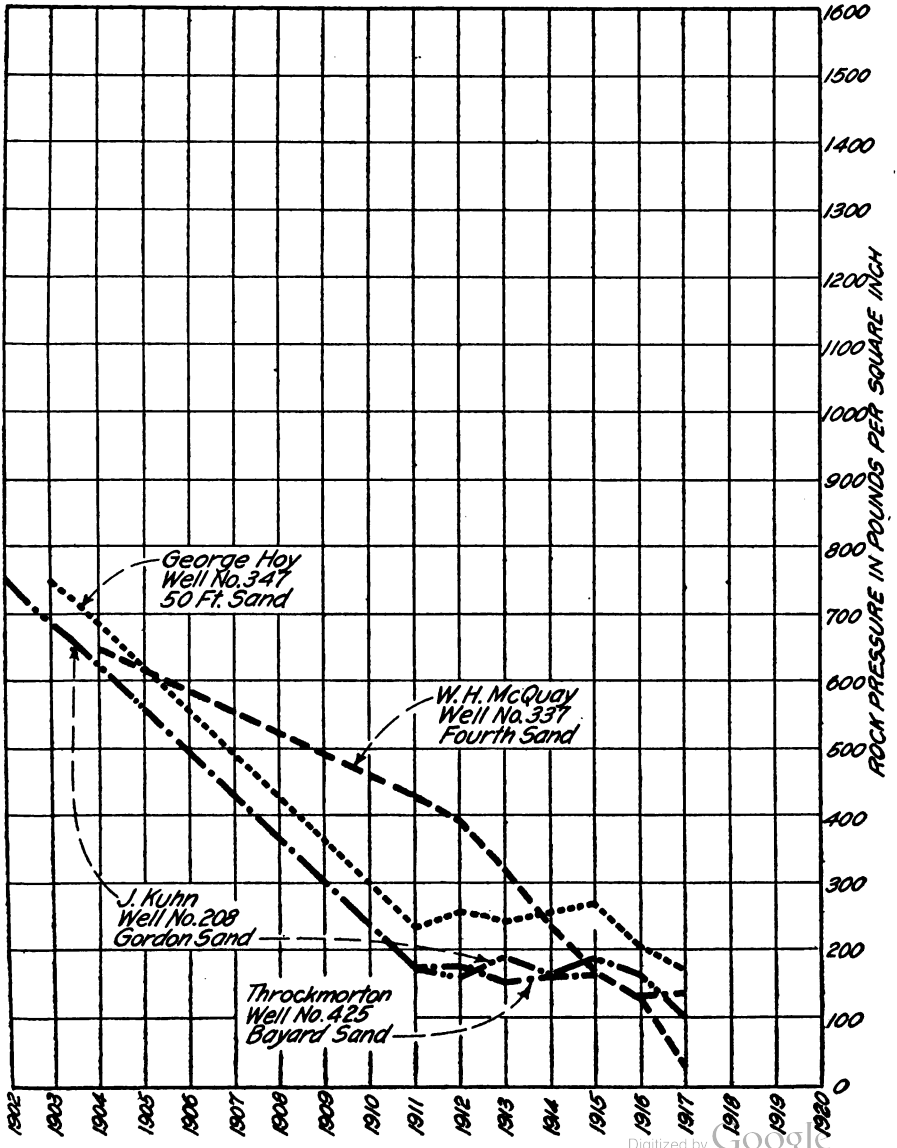
For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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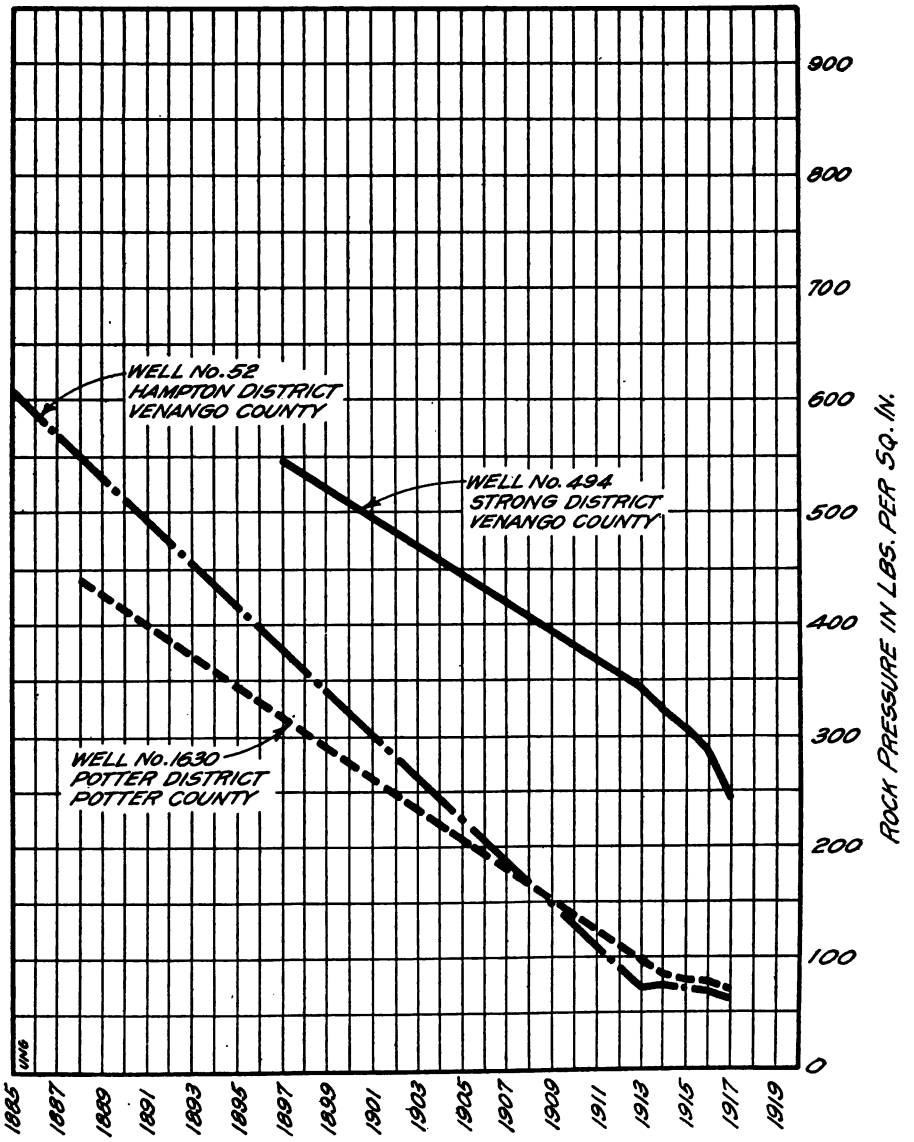
OF
THE UNITED NATURAL GAS COMPANY
IN
POTTER AND VENANGO CO'S, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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THE UNITED NATURAL GAS COMPANY
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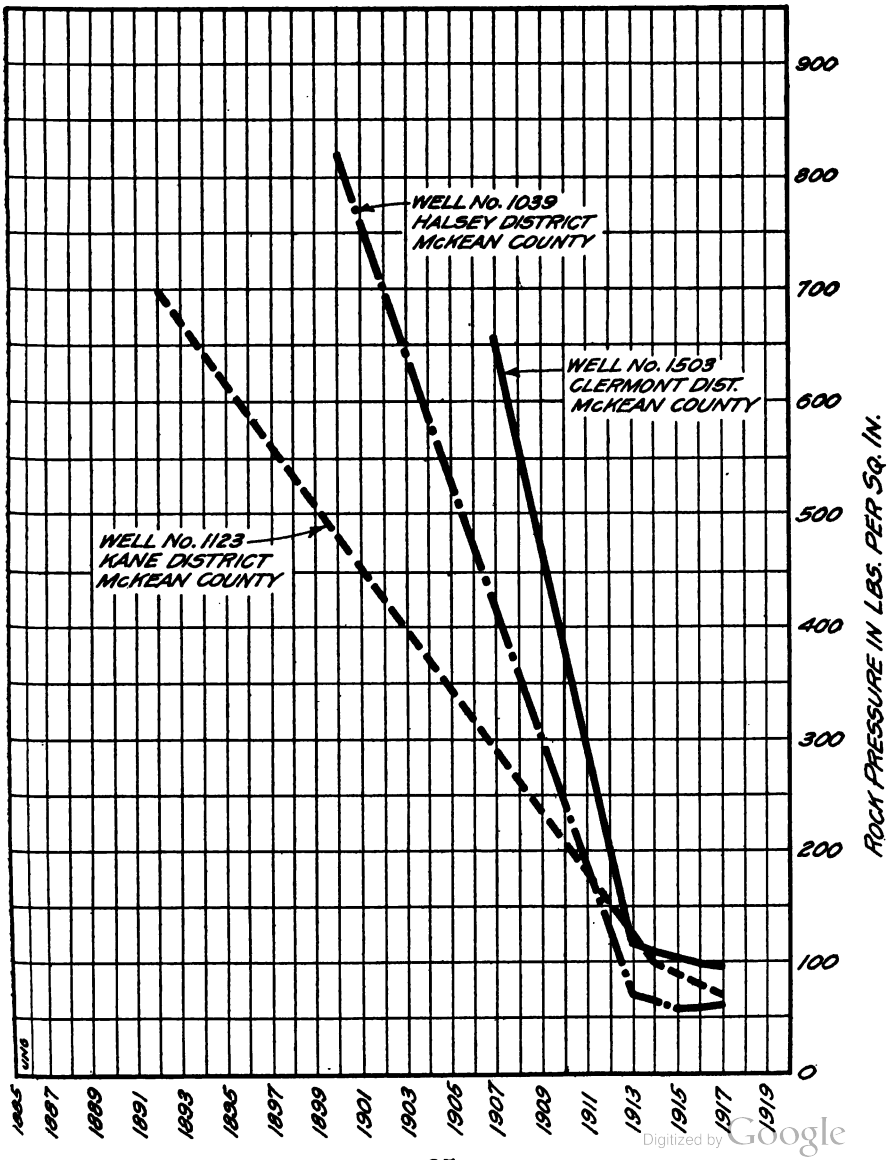
MCKEAN COUNTY, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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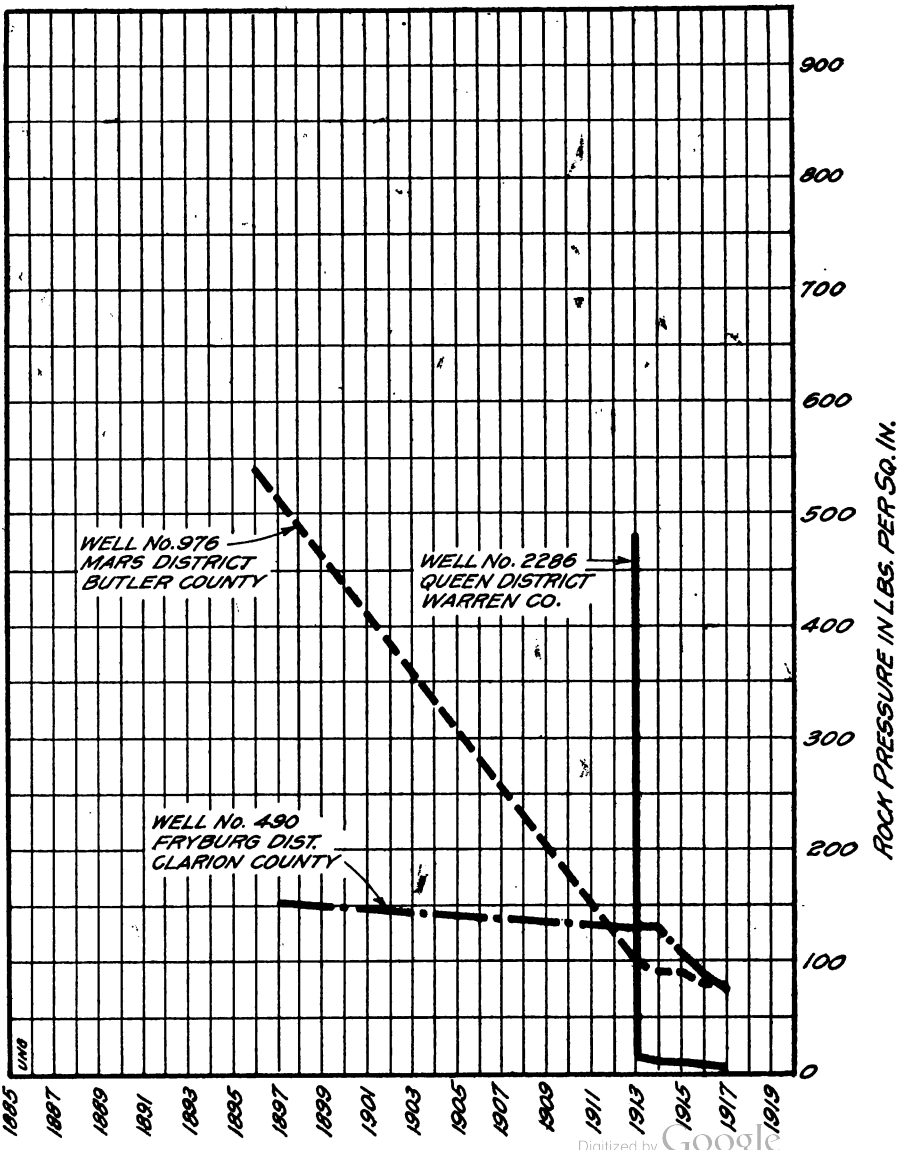
ROCK PRESSURE DECLINE
OF
TYPICAL NATURAL GAS WELLS
OF
THE UNITED NATURAL GAS COMPANY
IN
CLARION, WARREN, AND BUTLER CO'S, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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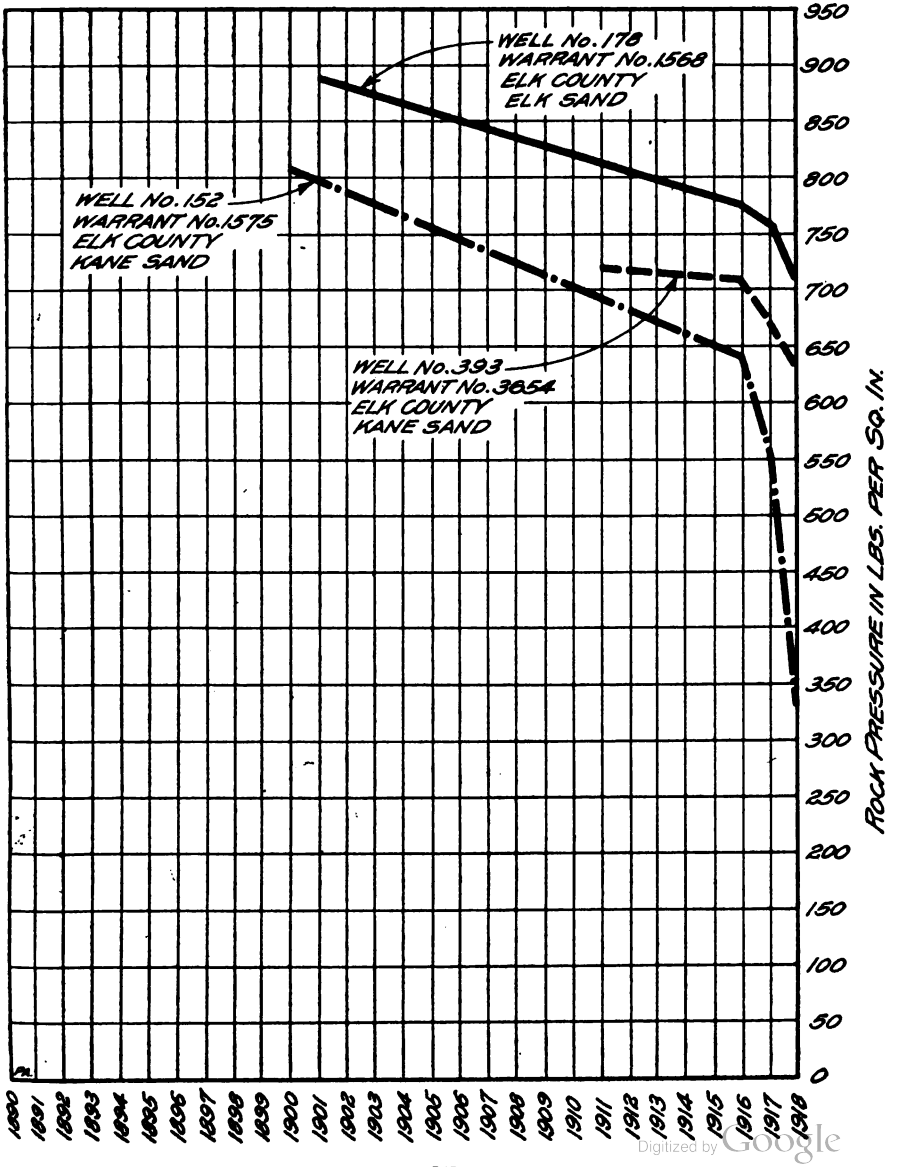
ROCK PRESSURE DECLINE
OF
TYPICAL NATURAL GAS WELLS
OF
THE PENNSYLVANIA GAS COMPANY
IN
ELK COUNTY, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



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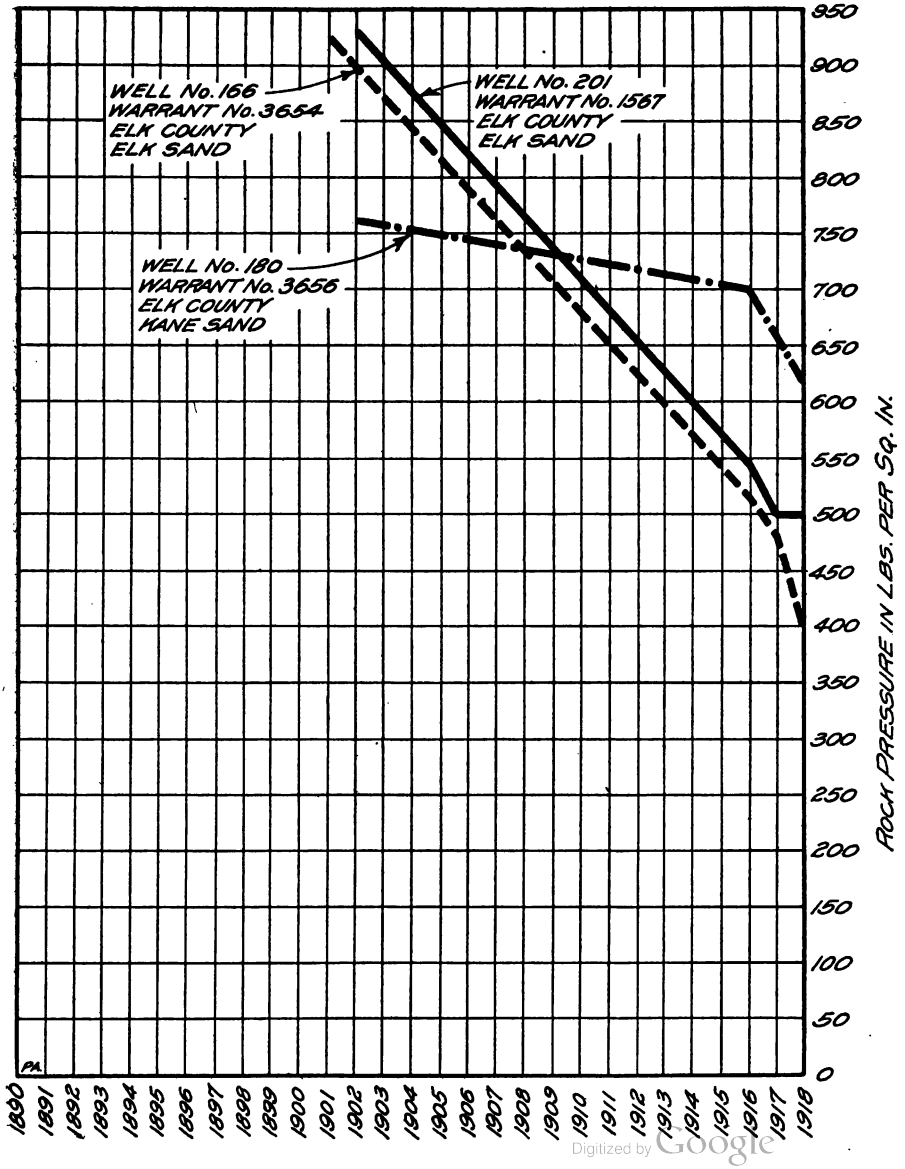

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OF
THE PENNSYLVANIA GAS COMPANY
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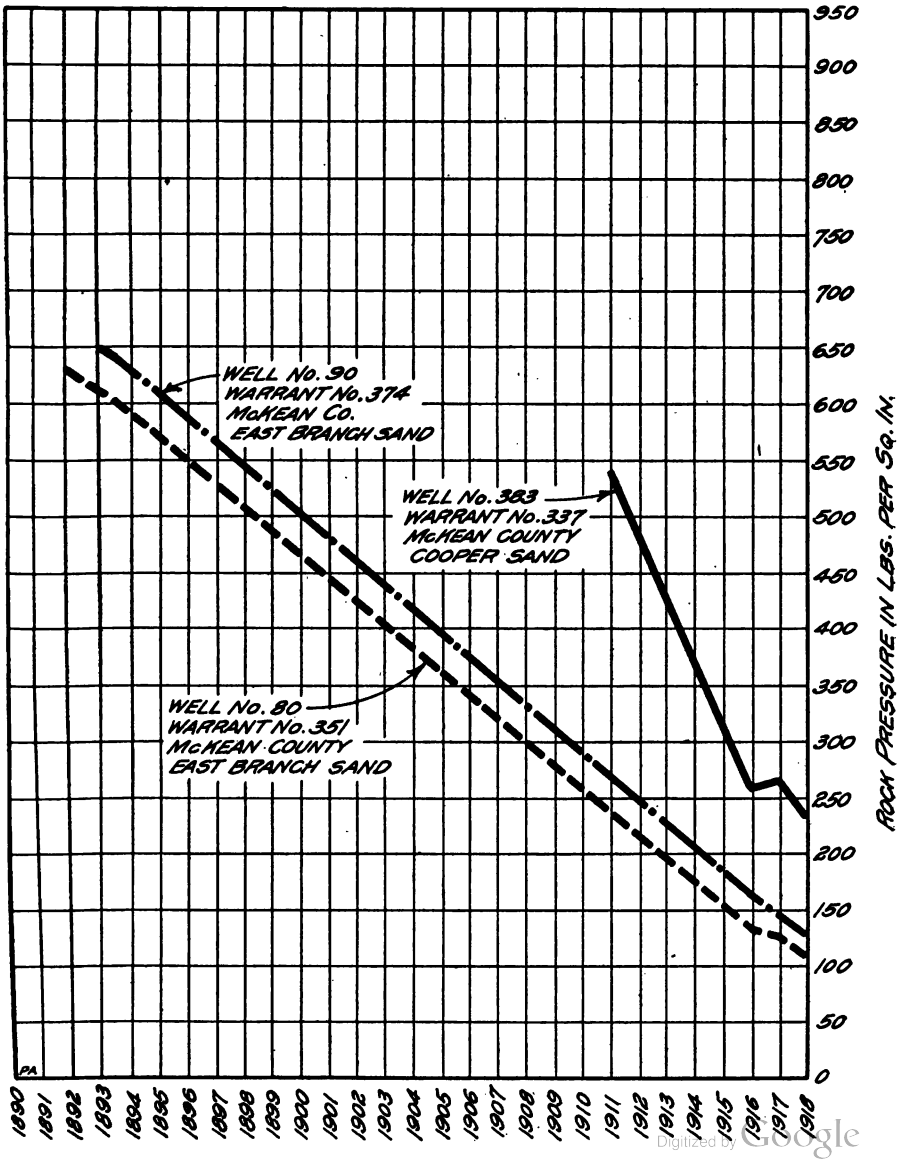

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ROCK PRESSURE DECLINE
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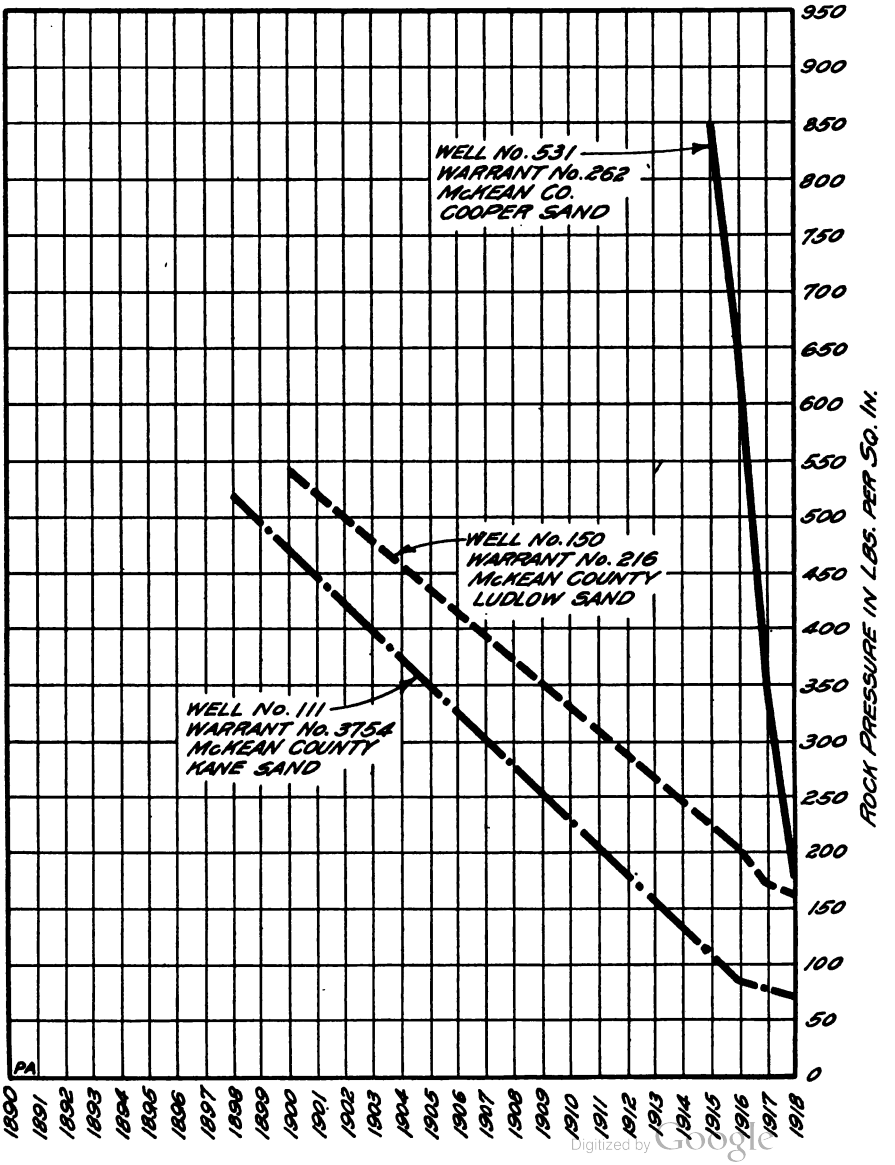

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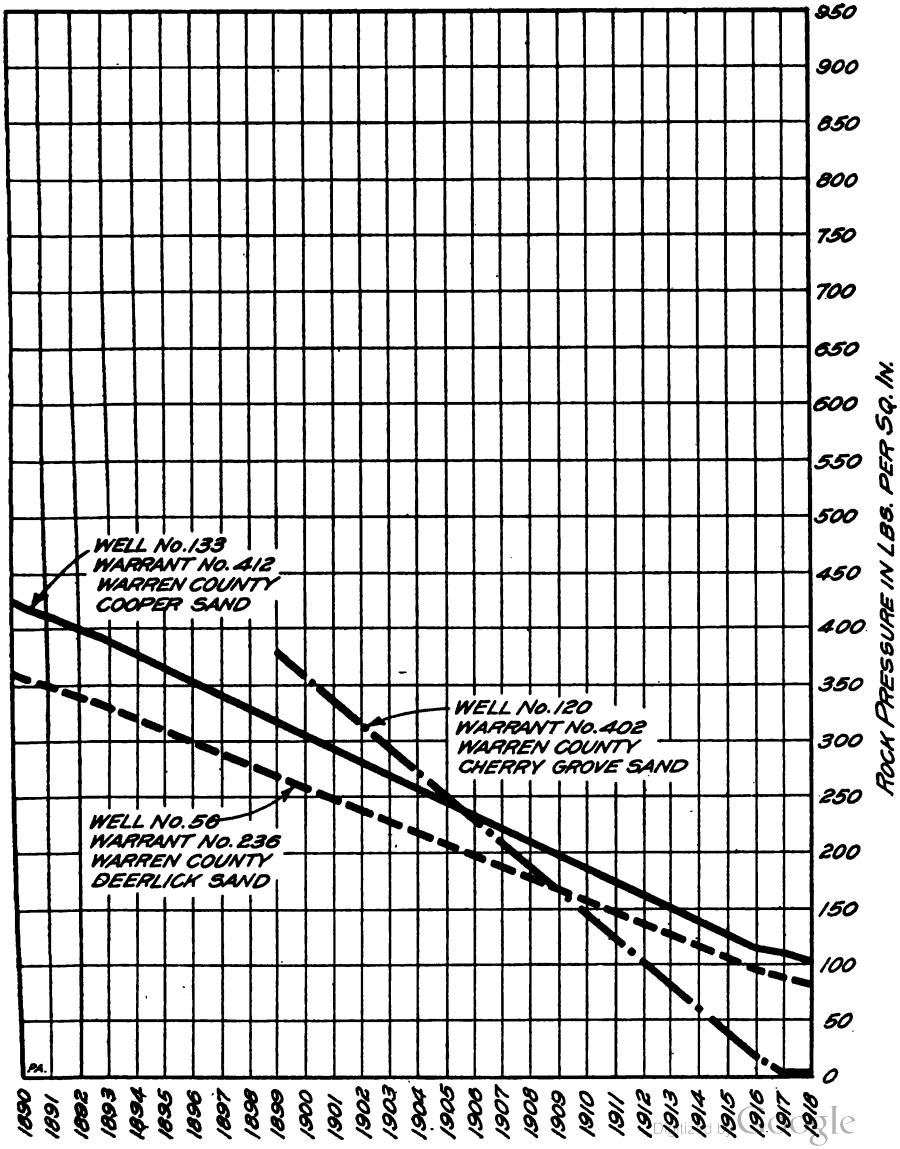
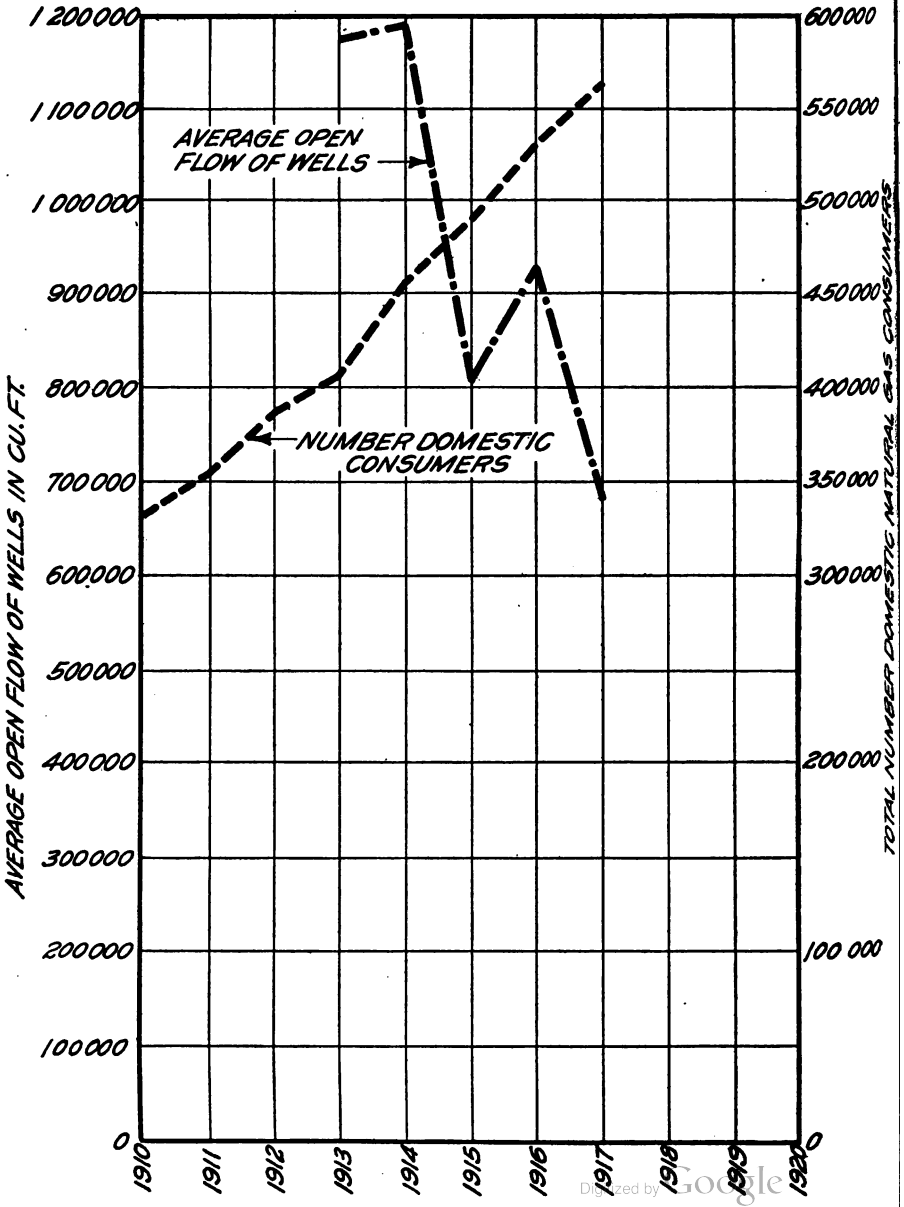
ROCK PRESSURE DECLINE
OF
TYPICAL NATURAL GAS WELLS
OF
THE PENNSYLVANIA GAS COMPANY
IN
WARREN COUNTY, PENNSYLVANIA

For definition of "rock pressure" and "reasons why rock pressure must decline," see pages 16 and 17 attached Smithsonian Bulletin.



RELATION OF NUMBER DOMESTIC CONSUMERS AND AVERAGE OPEN FLOW OF WELLS OF THE HOPE NATURAL GAS COMPANY

This shows the marked decline in open flow of wells drilled with the simultaneous increase in number of domestic consumers and, therefore, increased demands for service with decreased capacity to serve.



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DECLINE IN

AVERAGE OPEN FLOW OF NEW WELLS

OF

THE UNITED NATURAL GAS COMPANY

For meaning of the term "open flow" and discussion of "misleading well capacity" see pages 19 and 20 attached Smithsonian Bulletin.

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DECLINE IN
AVERAGE OPEN FLOW OF NEW WELLS
OF
THE PENNSYLVANIA GAS COMPANY

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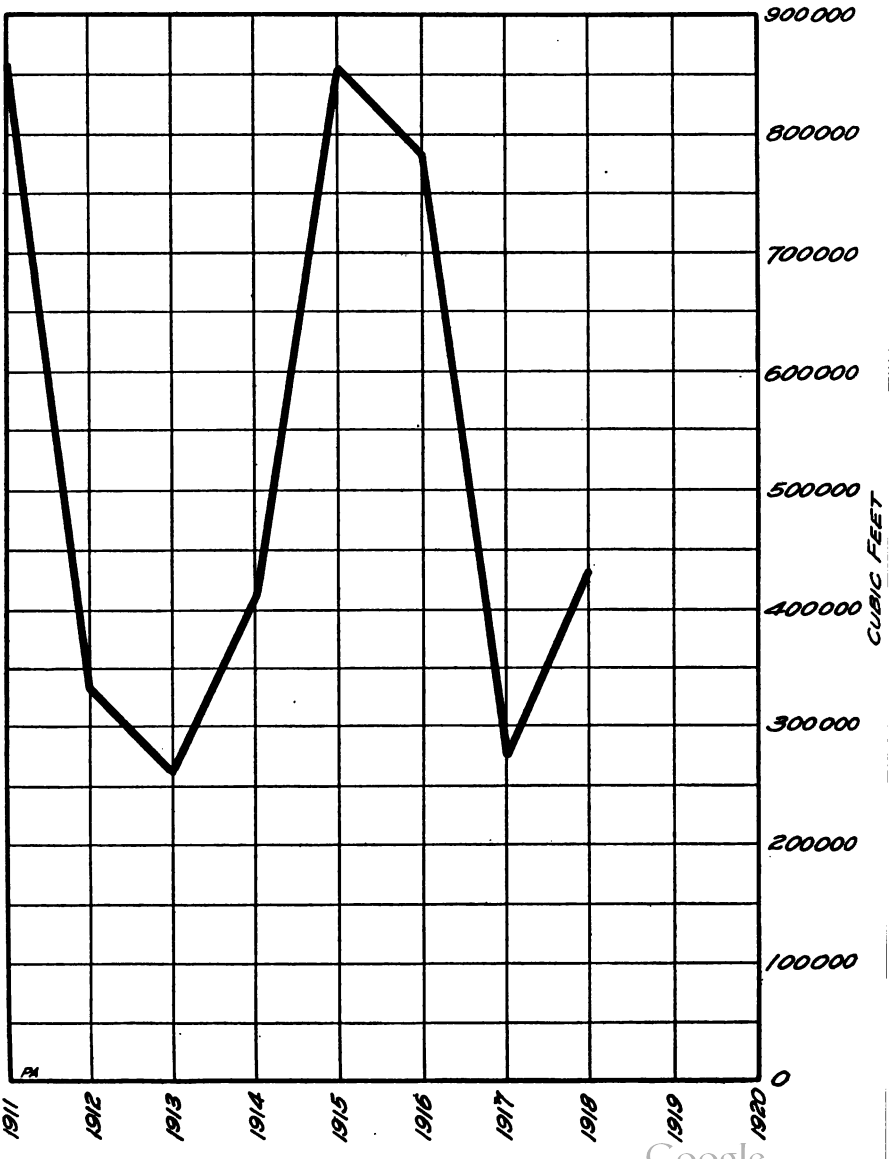

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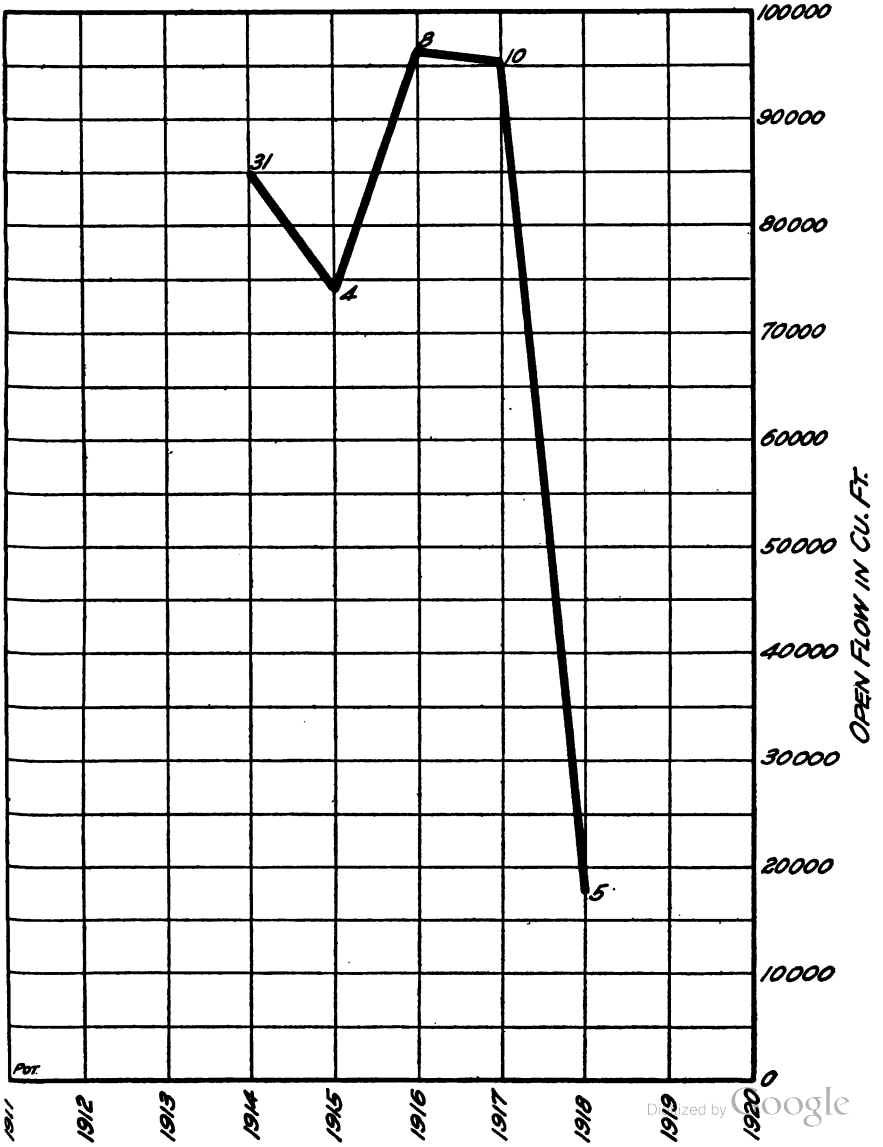
DECLINE IN AVERAGE OPEN FLOW OF NEW WELLS OF THE POTTER GAS COMPANY

This does not include the wells of the Mountain Gas Company, which was sold to The Potter Gas Company in March, 1917. The average open flow of nine new wells drilled on the Mountain Gas Company tract in 1917 was 444,000 cu. ft., and this declined to an average of 312,000 cu. ft. for eleven wells in 1918.

The figures adjacent to the curve indicate the number of wells averaged to secure the average results plotted.

For meaning of the term "open flow" and discussion of "misleading well capacity" see pages 19 and 20 attached Smithsonian Bulletin.



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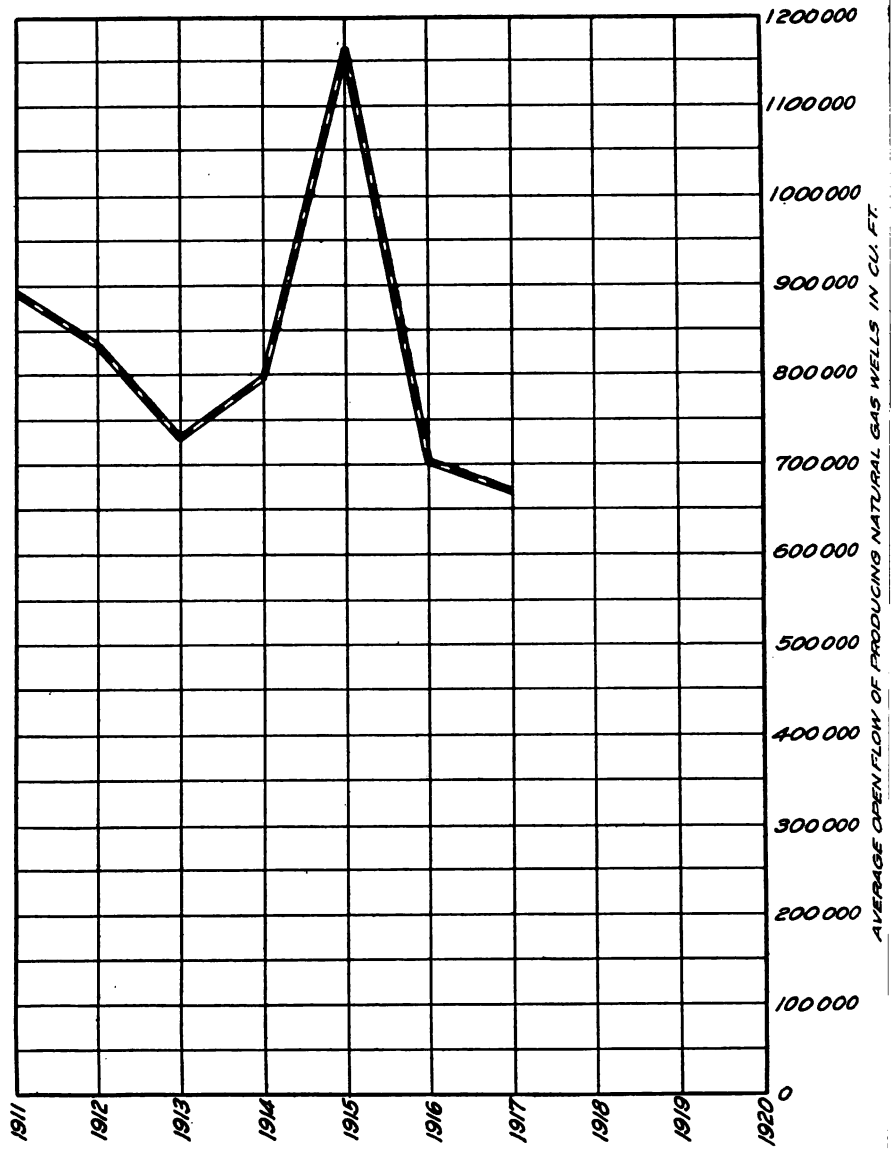
DECLINE IN
AVERAGE OPEN FLOW OF PRODUCING GAS WELLS
DRILLED BY
THE PEOPLES NATURAL GAS COMPANY

For meaning of the term "open flow" and discussion of "misleading well capacity," see pages 19 and 20 attached Smithsonian Bulletin.



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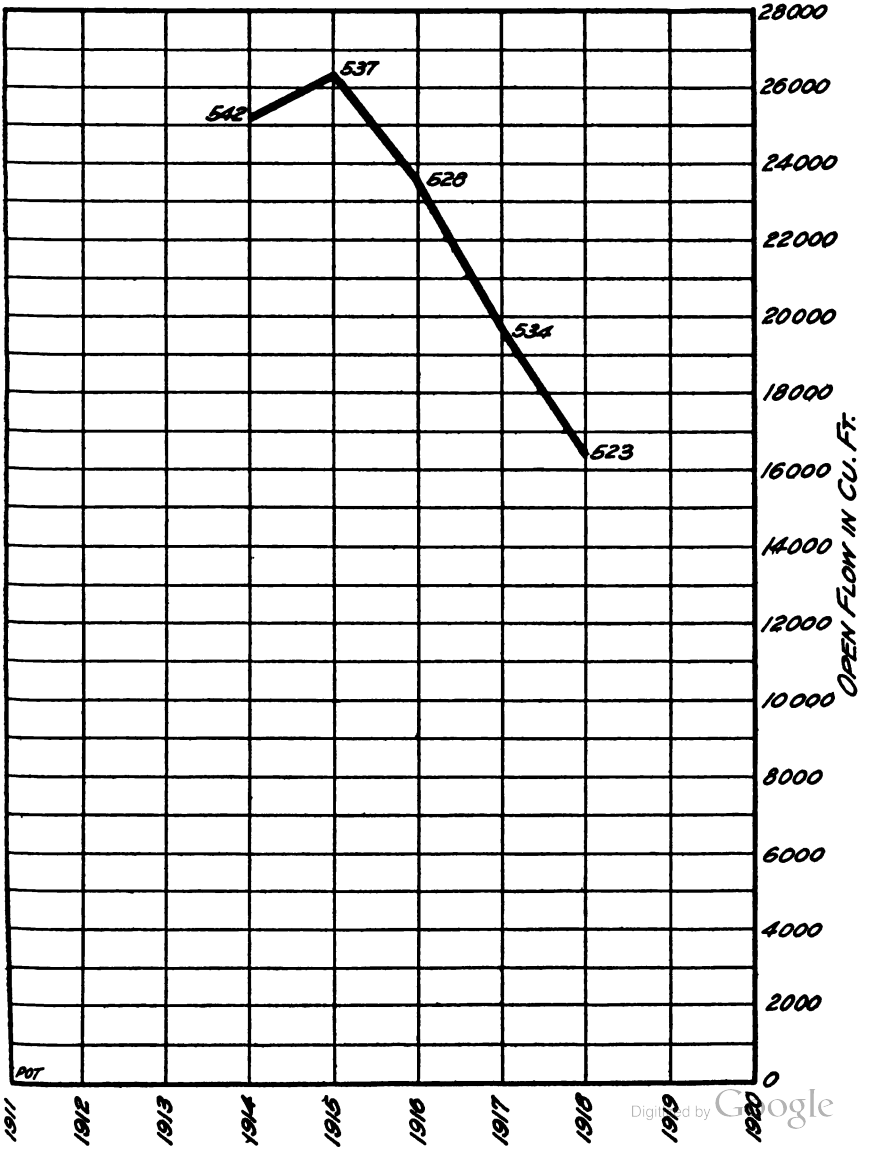
DECLINE IN AVERAGE OPEN FLOW
OF
PRODUCING WELLS
OF
THE POTTER GAS COMPANY

This does not include the wells of the Mountain Gas Company which was sold to The Potter Gas Company in March, 1917. The average open flow of the Mountain Gas Company wells in 1917 was 135,000 cu. ft. and this declined to 82,000 cu. ft. in 1918.

The figures adjacent to the curve indicate the number of wells averaged to secure the average results plotted.

For meaning of the term "open flow" and discussion of "misleading well capacity" see pages 19 and 20 attached Smithsonian Bulletin.



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AVERAGE ANNUAL PRODUCTION PER WELL

OF

THE HOPE NATURAL GAS COMPANY

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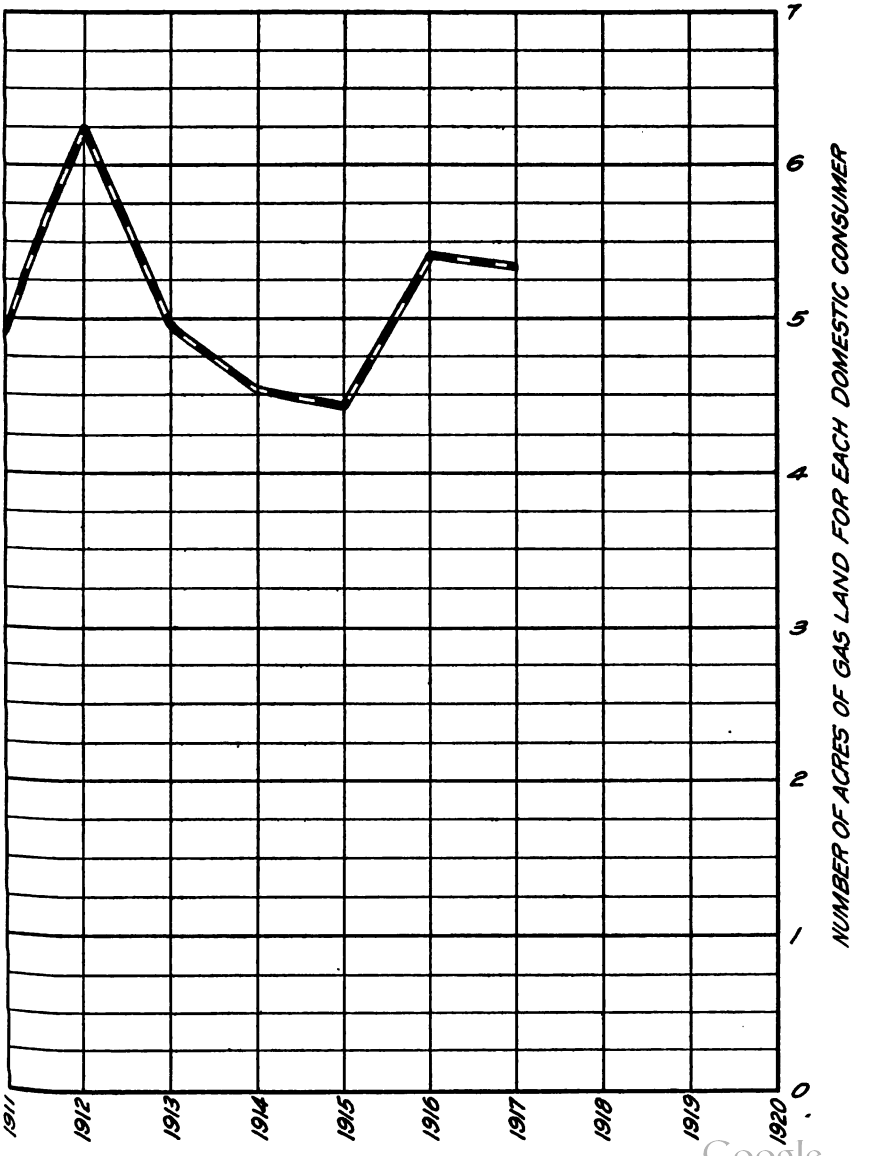
NUMBER ACRES NATURAL GAS LAND RESERVED FOR FUTURE SERVICE FOR EACH DOMESTIC CONSUMER OF THE PEOPLES NATURAL GAS COMPANY

For discussion of "reserve acreage," see pages 8 and 9 attached Smithsonian Bulletin.



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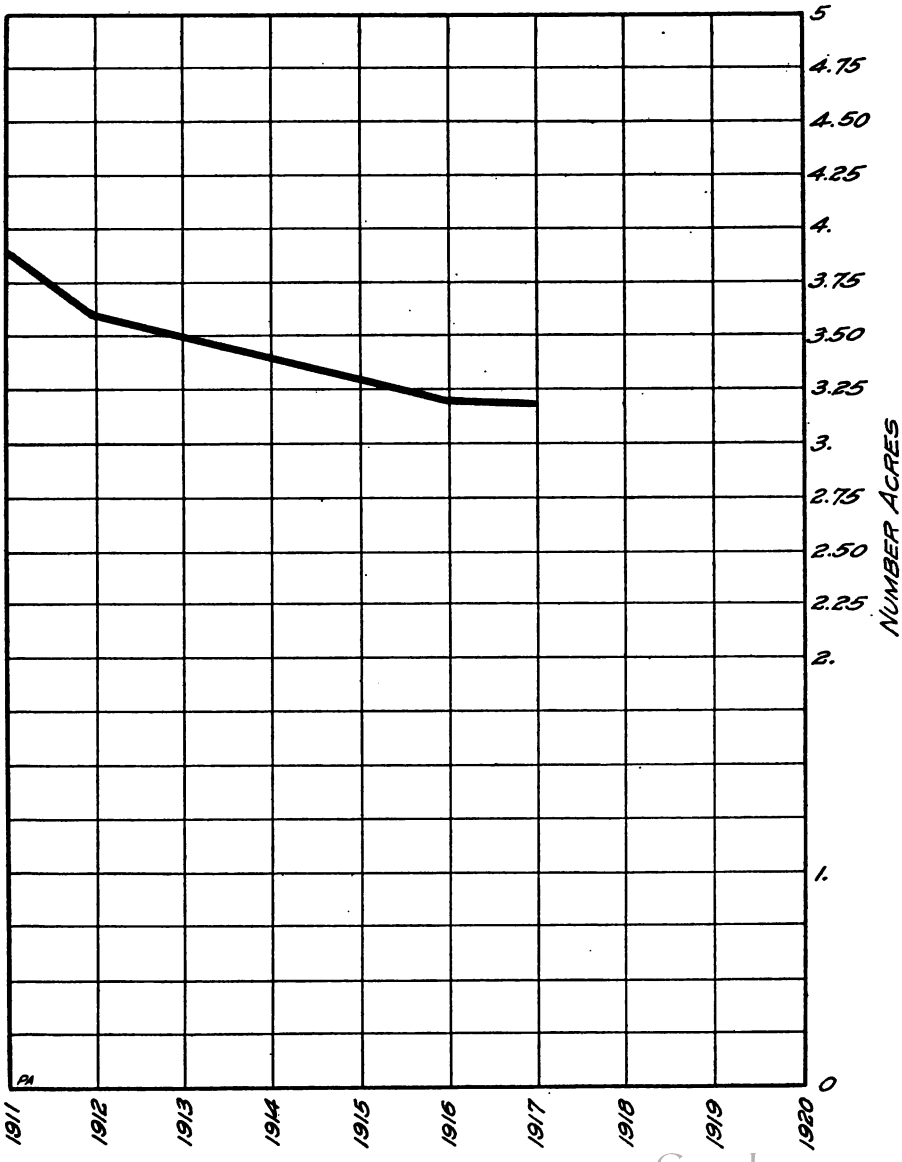
DECLINE IN
NUMBER ACRES NATURAL GAS LAND OWNED
PER DOMESTIC CONSUMER
OF
THE PENNSYLVANIA GAS COMPANY

For discussion of "reserve acreage," see pages 8 and 9 attached Smithsonian Bulletin.



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DECLINE IN

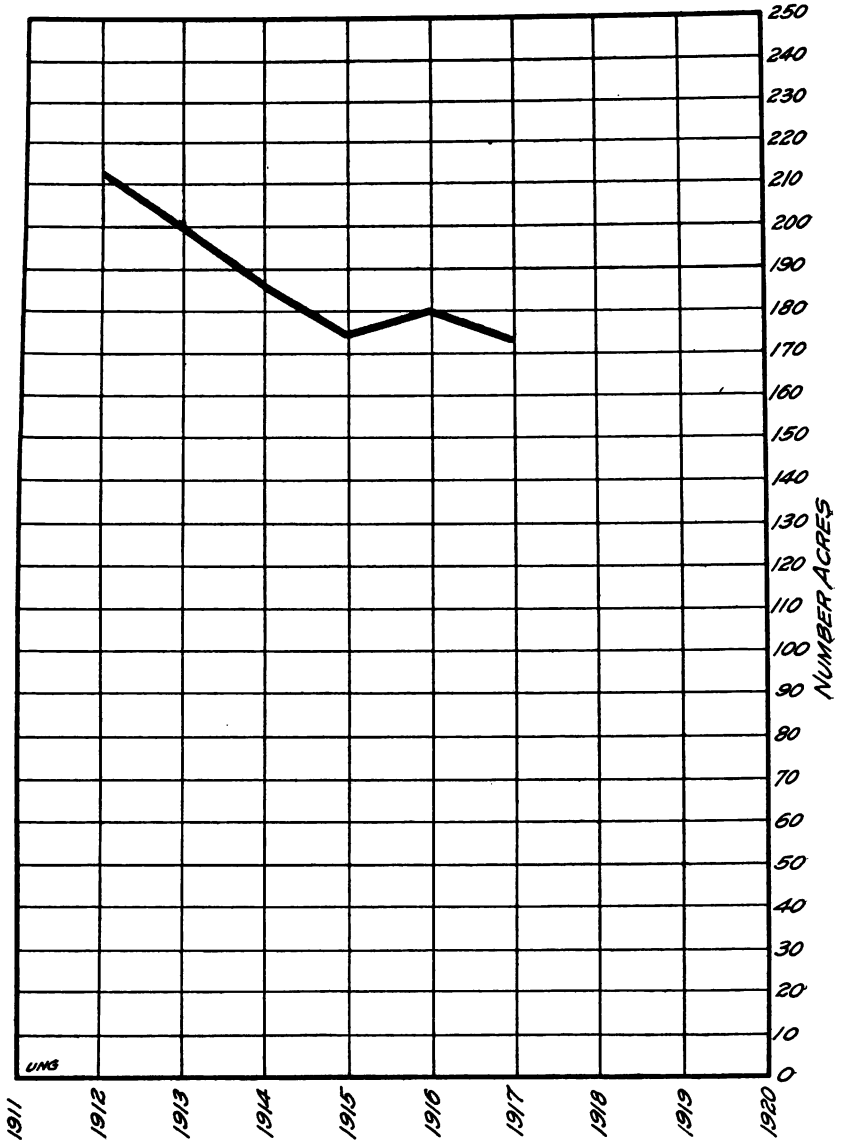
NUMBER ACRES NATURAL GAS LAND OWNED

PER AVAILABLE NATURAL GAS WELL

OF

THE UNITED NATURAL GAS COMPANY

For discussion of "reserve acreage," see pages 8 and 9 attached Smithsonian Bulletin.



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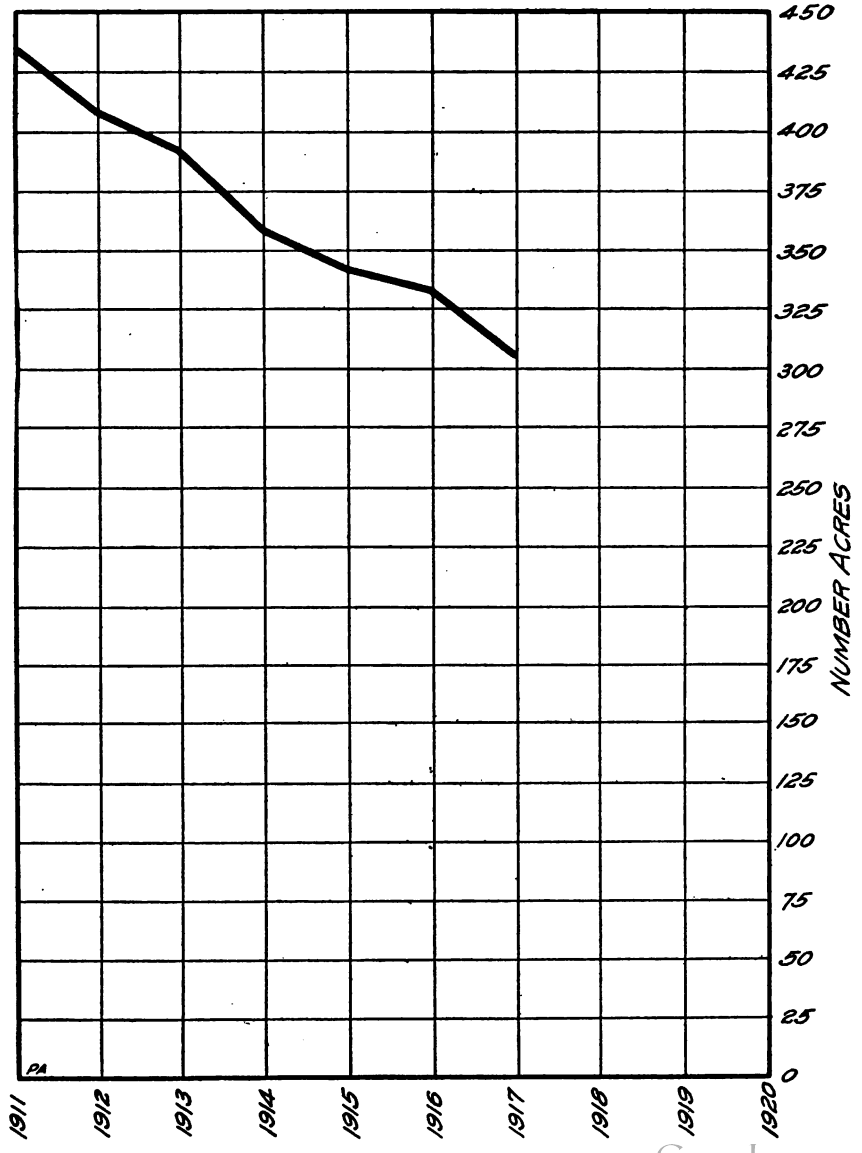
DECLINE IN
NUMBER ACRES NATURAL GAS LAND OWNED
PER AVAILABLE NATURAL GAS WELL
OF
THE PENNSYLVANIA GAS COMPANY

For discussion of "reserve acreage," see pages 8 and 9 attached Smithsonian Bulletin.



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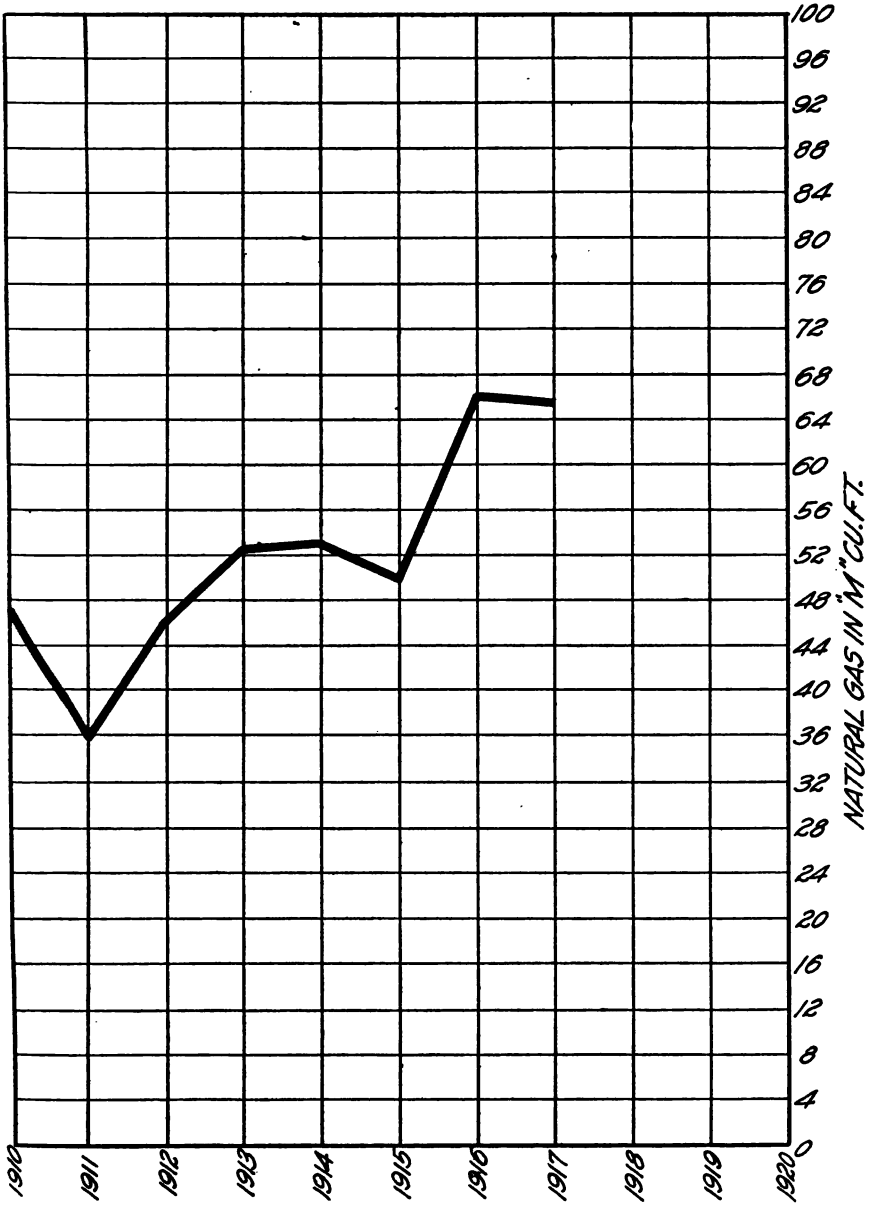
"M" CU. FT. NATURAL GAS REMOVED PER ANNUM PER ACRE NATURAL GAS LAND OWNED BY THE HOPE NATURAL GAS COMPANY



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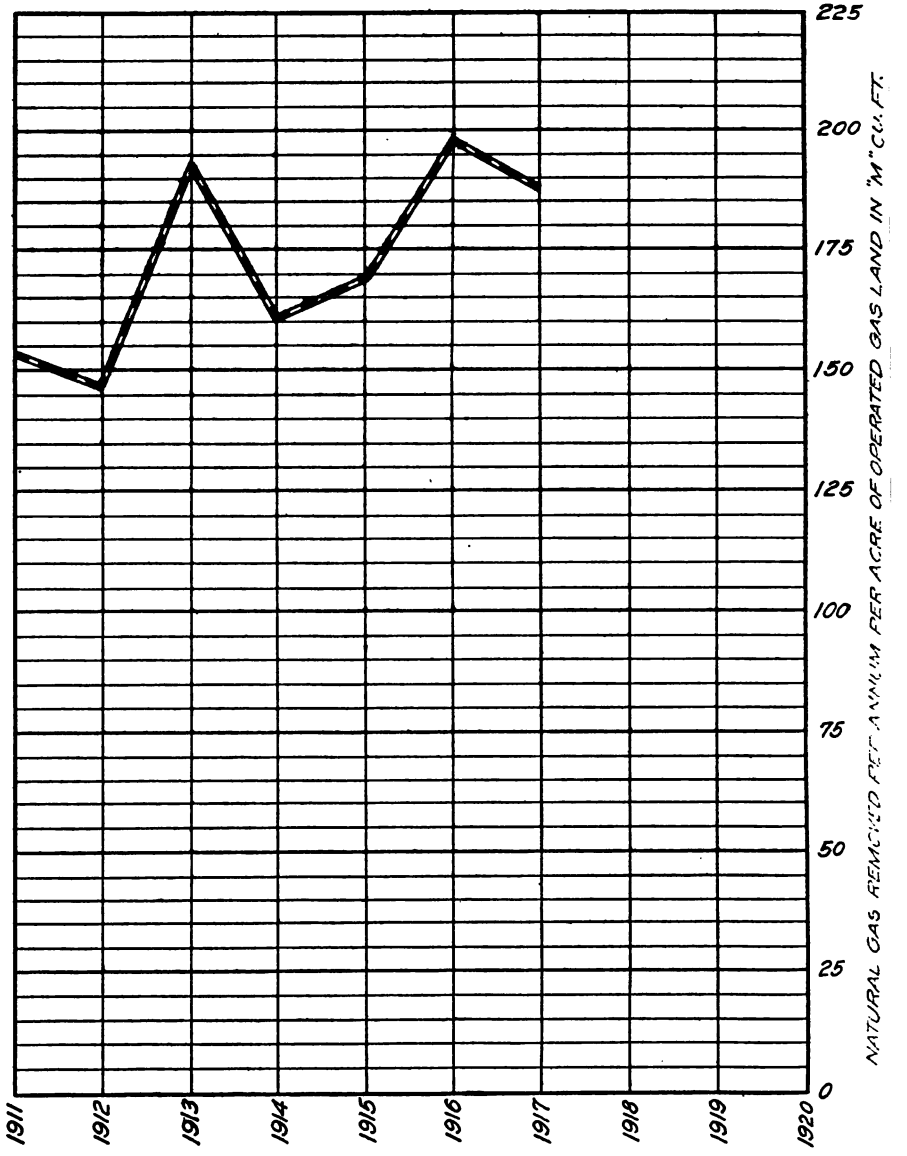
"M" CU. FT. NATURAL GAS REMOVED PER ANNUM PER ACRE OF OPERATED NATURAL GAS LAND OF THE PEOPLES NATURAL GAS COMPANY



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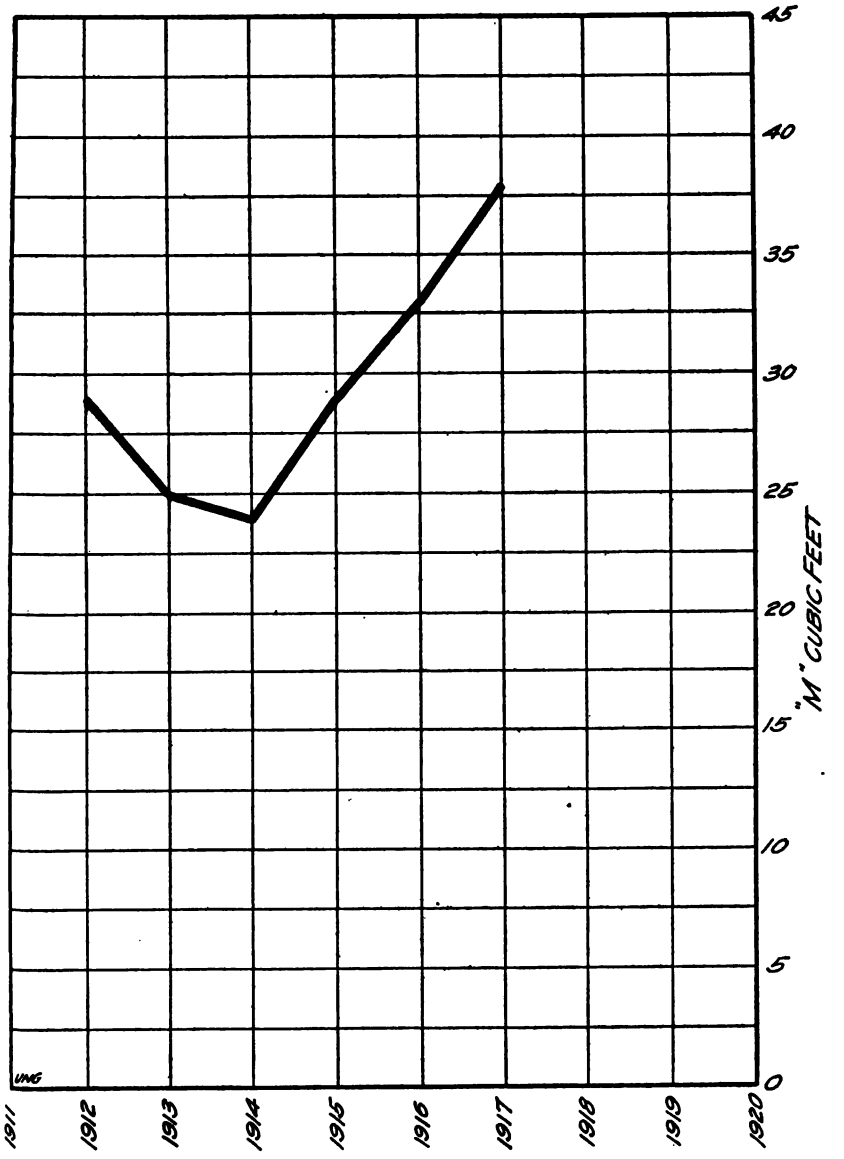
"M" CU. FT. NATURAL GAS REMOVED PER ANNUM

PER ACRE NATURAL GAS LAND OWNED

BY

THE UNITED NATURAL GAS COMPANY



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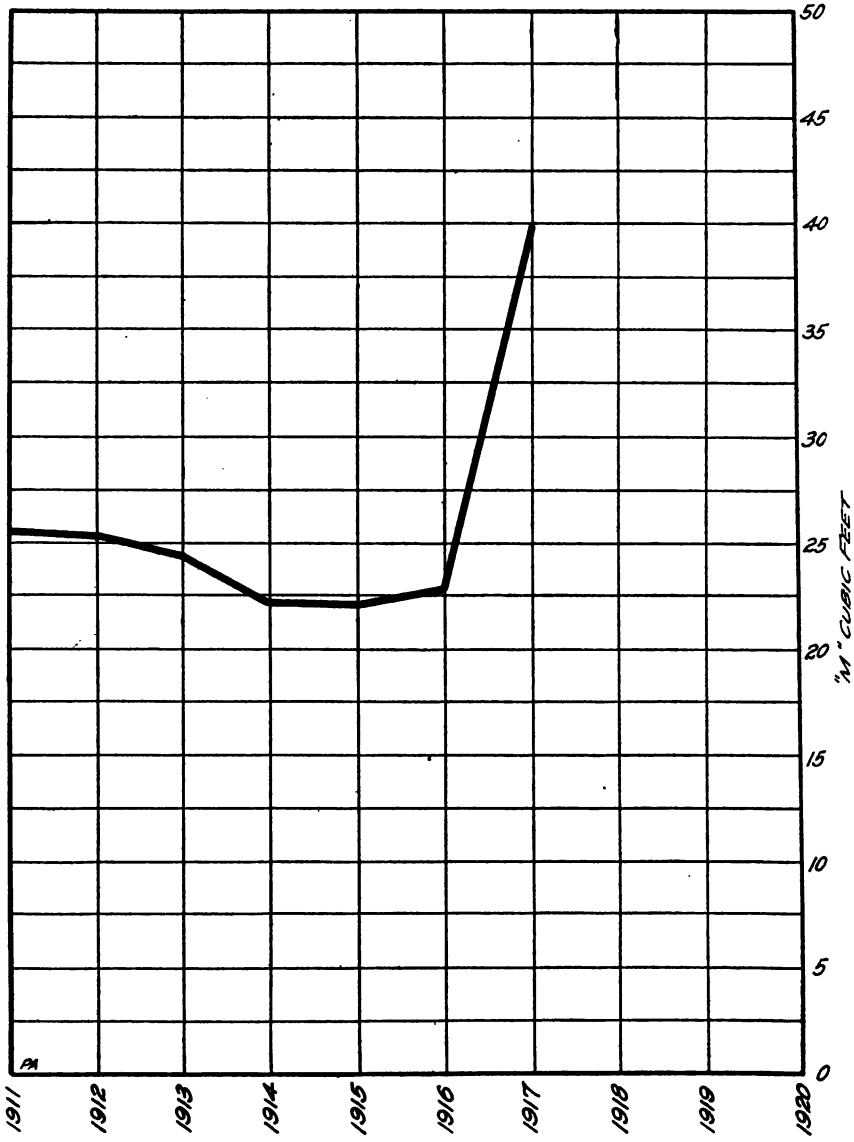

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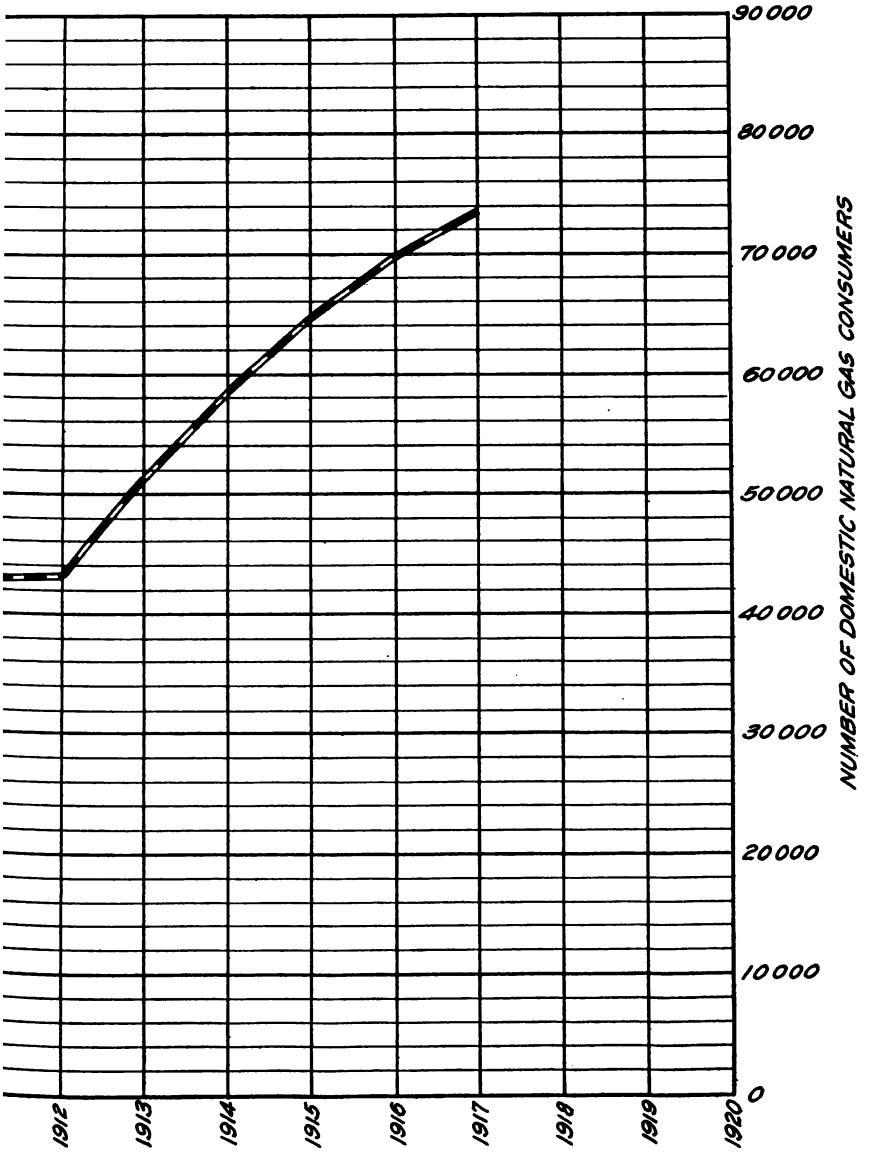
INCREASE IN

NUMBER OF DOMESTIC NATURAL GAS CONSUMERS

OF

THE PEOPLES NATURAL GAS COMPANY



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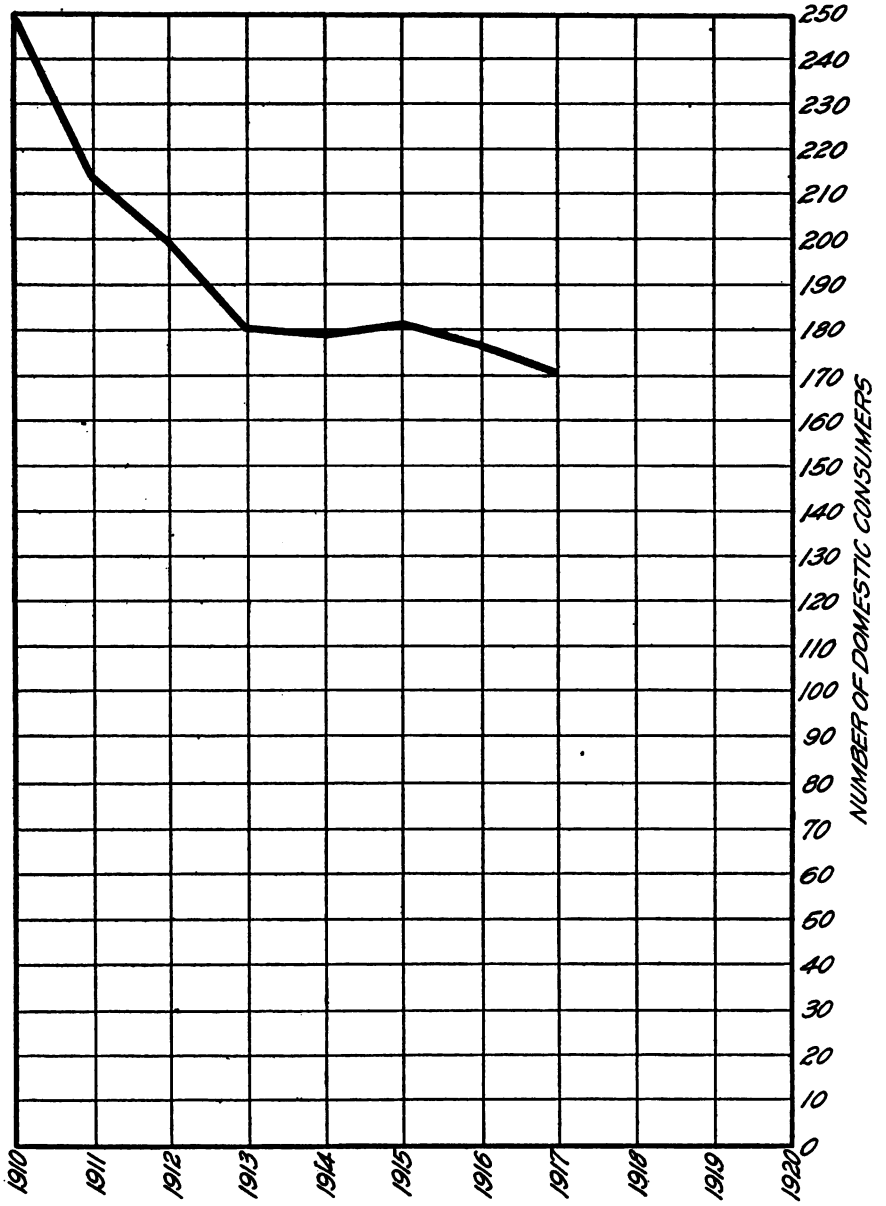
DECLINE IN
NUMBER OF DOMESTIC CONSUMERS
THAT CAN BE SERVED BY EACH WELL
OF
THE HOPE NATURAL GAS COMPANY



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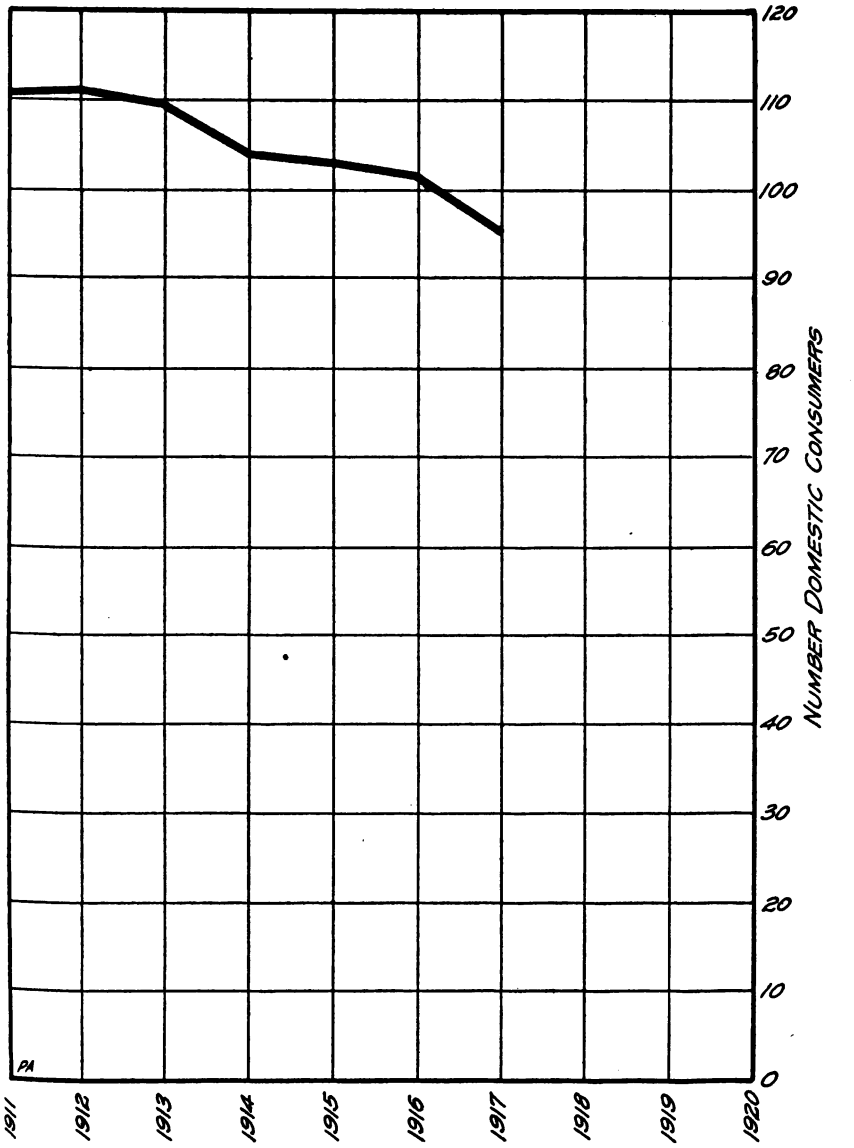
DECLINE IN
NUMBER OF DOMESTIC CONSUMERS
THAT CAN BE SERVED BY EACH WELL
OF
THE PENNSYLVANIA GAS COMPANY



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AVERAGE ANNUAL CONSUMPTION IN "M" CU. FT.
OF
DOMESTIC NATURAL GAS PER DOMESTIC CONSUMER
OF
THE HOPE NATURAL GAS COMPANY

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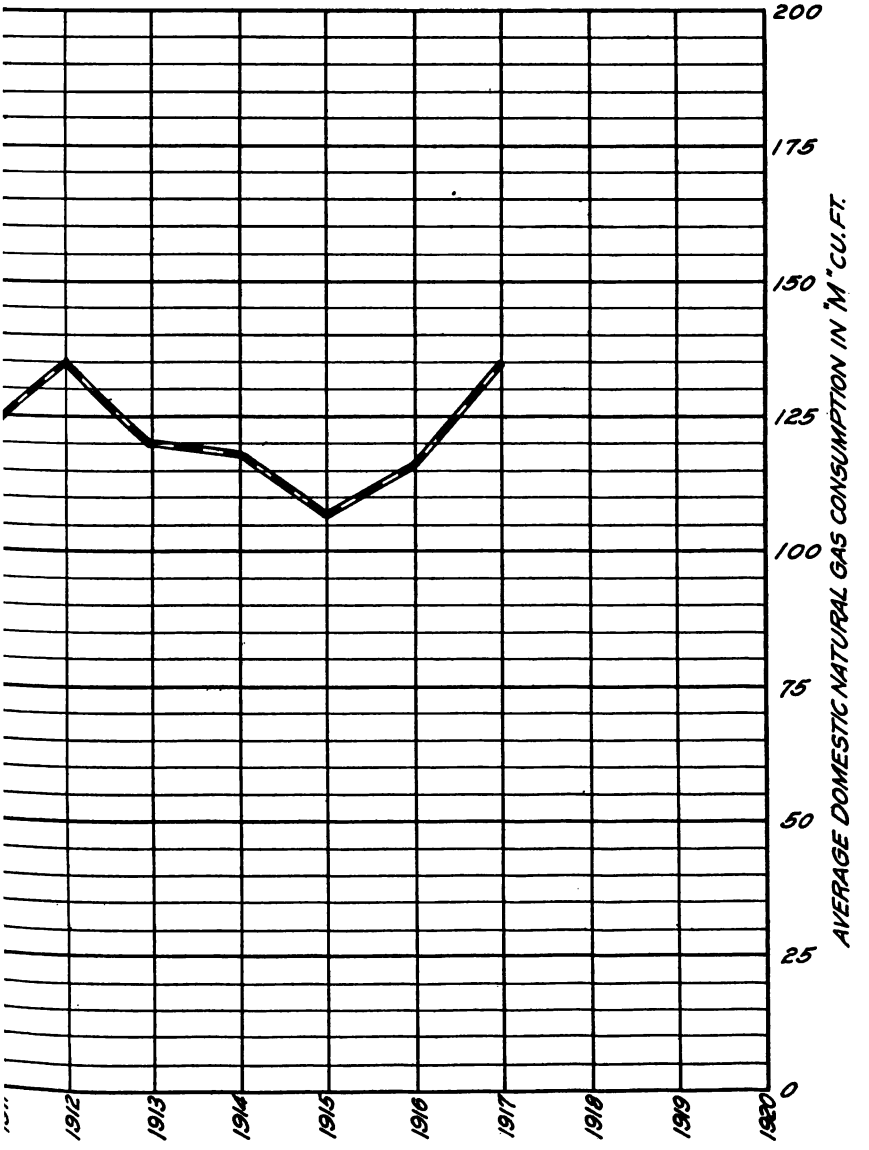
AVERAGE ANNUAL CONSUMPTION IN "M" CU. FT.
OF
DOMESTIC NATURAL GAS PER DOMESTIC CONSUMER
OF
THE PEOPLES NATURAL GAS COMPANY



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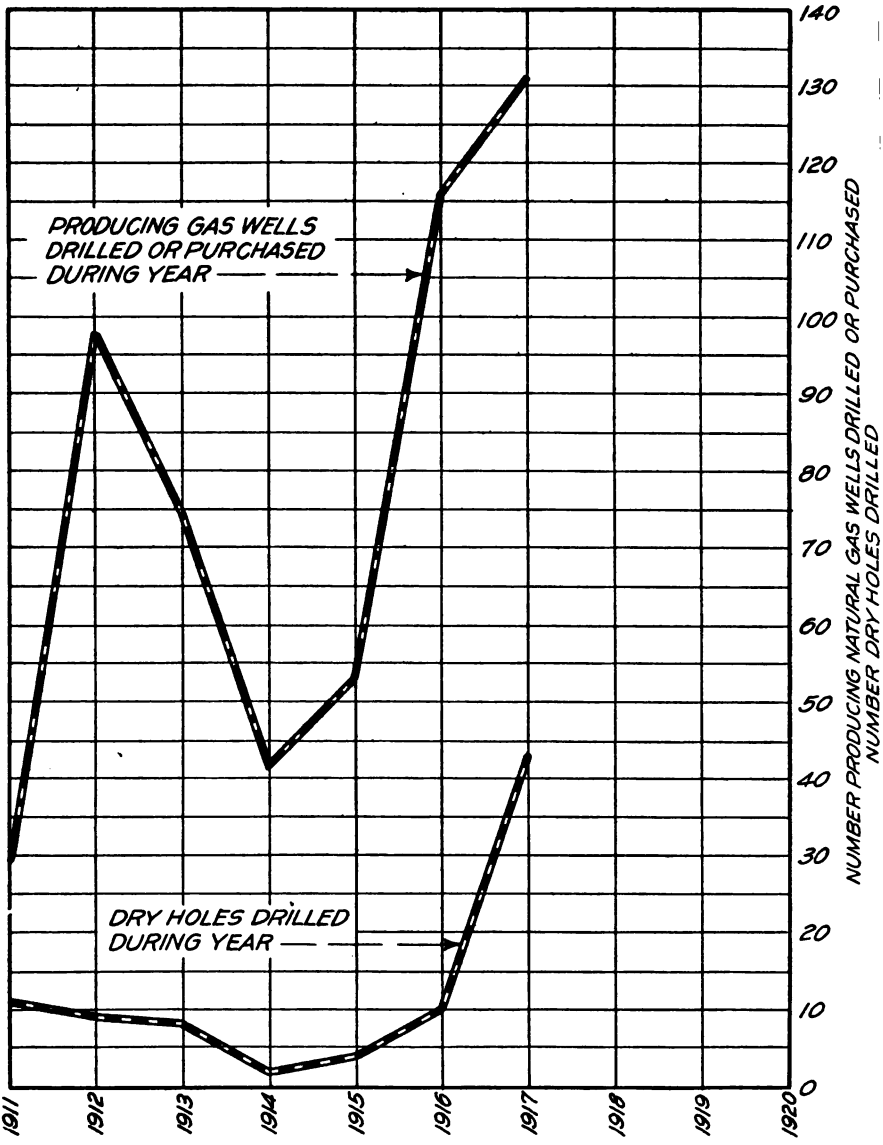
RELATION OF
NUMBER PRODUCING WELLS DRILLED OR PURCHASED
AND
DRY HOLES DRILLED
BY
THE PEOPLES NATURAL GAS COMPANY



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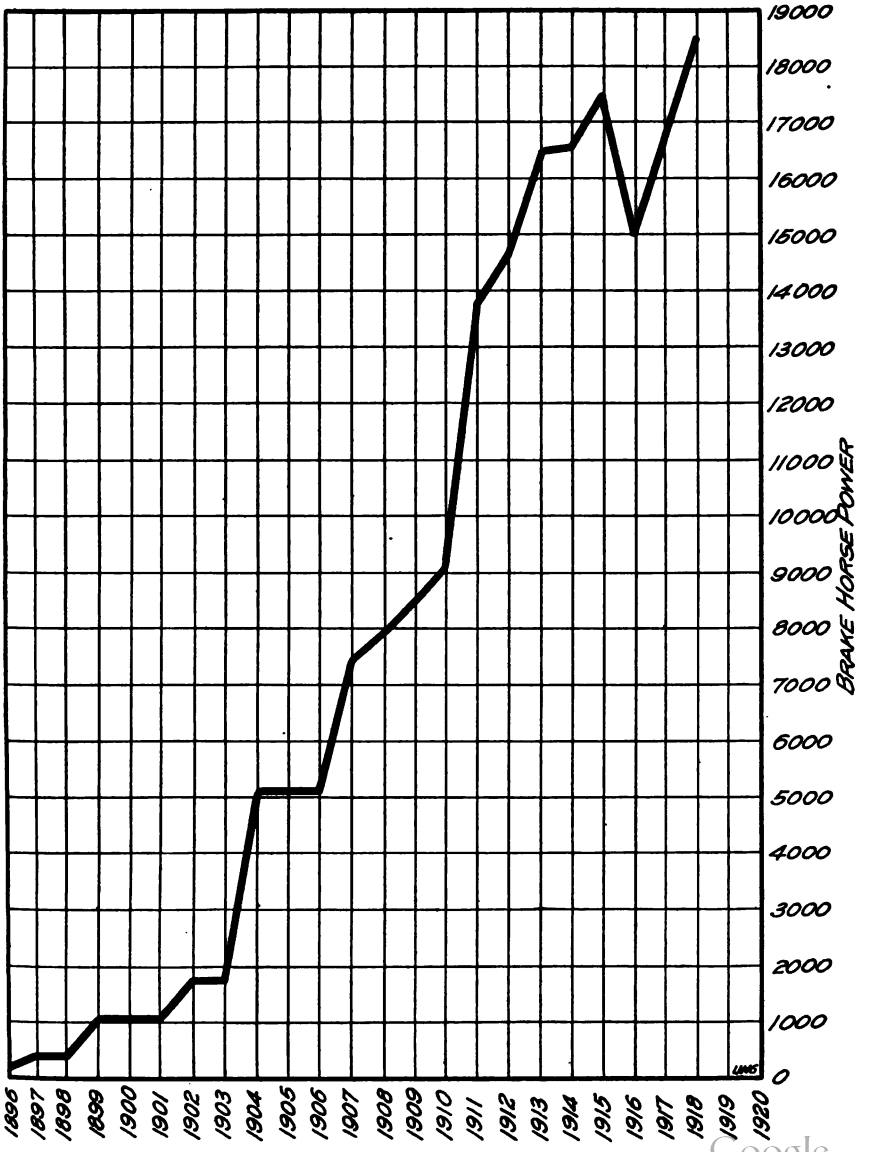
INCREASE IN CAPACITY
OF
NATURAL GAS COMPRESSING STATIONS
OF
THE UNITED NATURAL GAS COMPANY

This increase in horse power of compressing station capacity is made necessary by the increasing number of consumers and the decline in rock pressure, as discussed on page 29 attached Smithsonian Bulletin.



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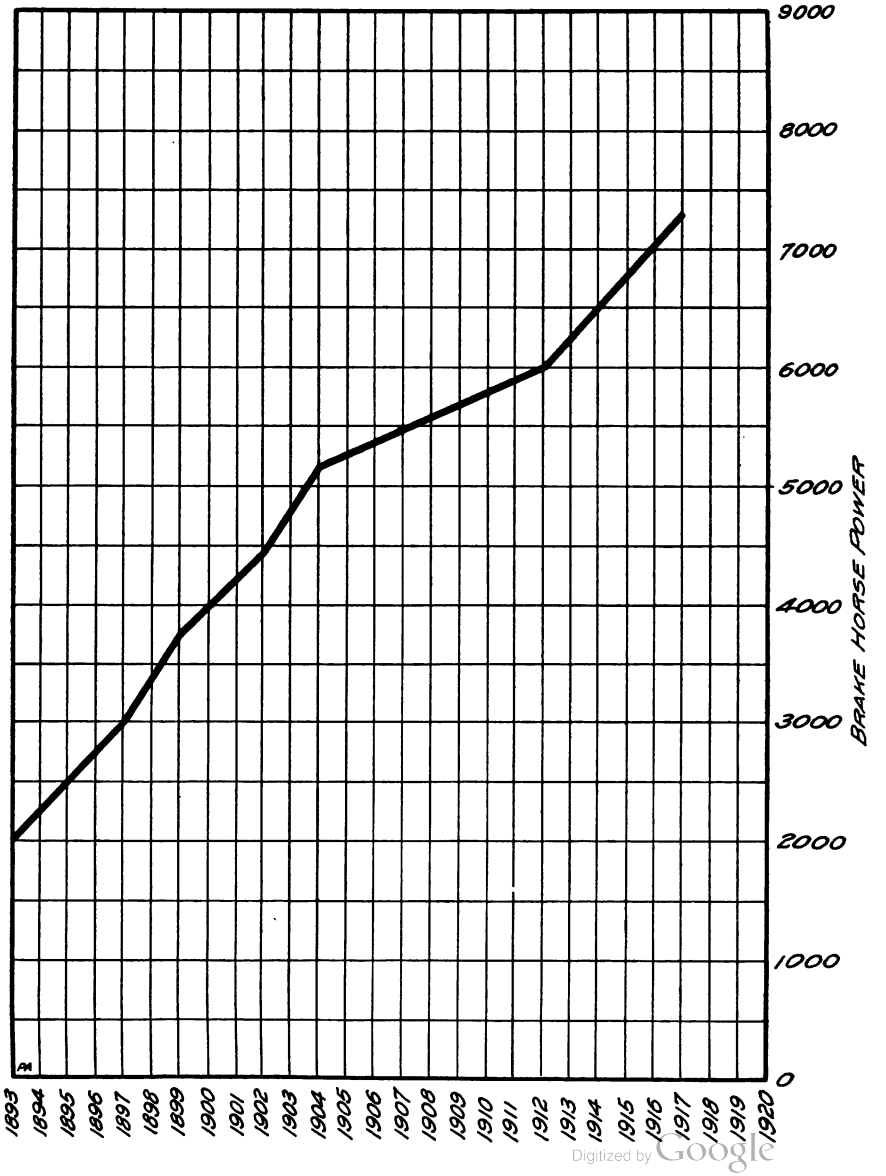

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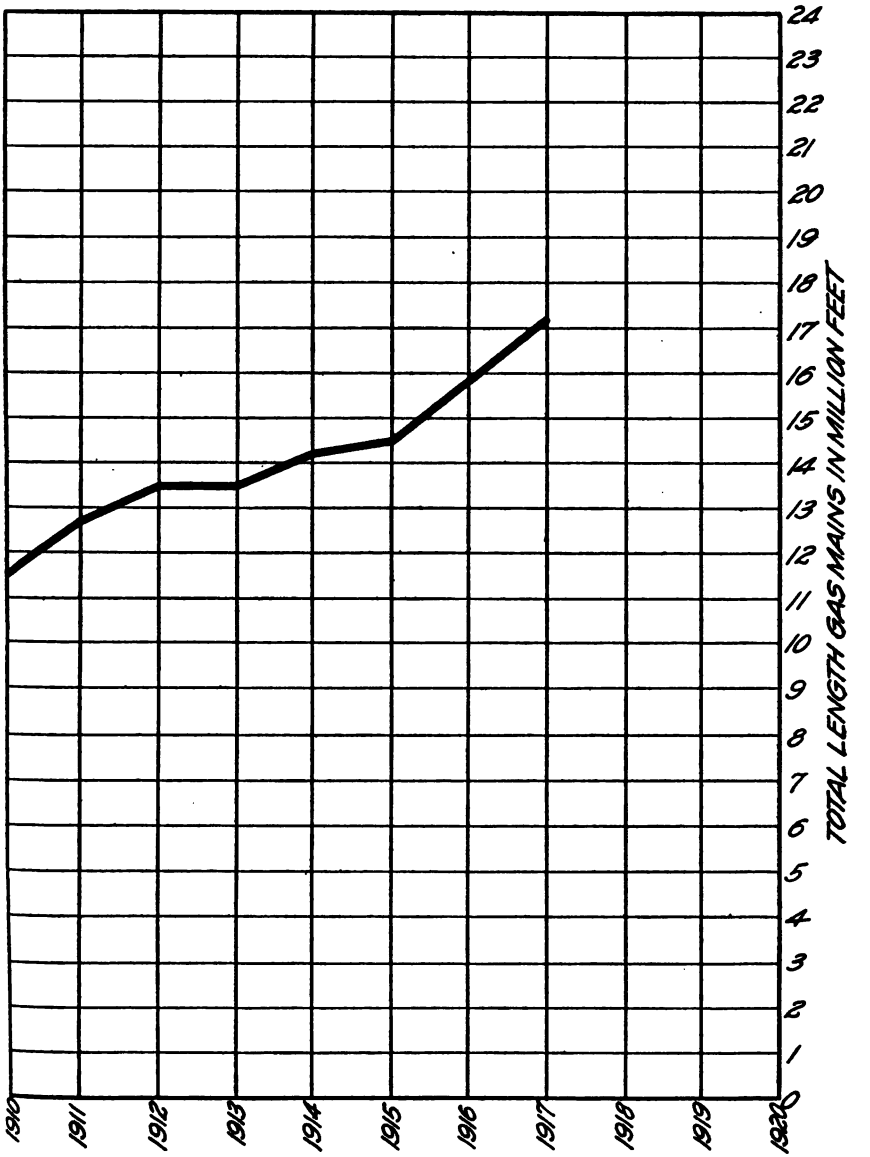
TOTAL LENGTH OF NATURAL GAS MAIN LINES
IN USE IN MILLION FEET
AS AN INDEX OF INCREASING LENGTH OF GAS HAUL
OF
THE HOPE NATURAL GAS COMPANY



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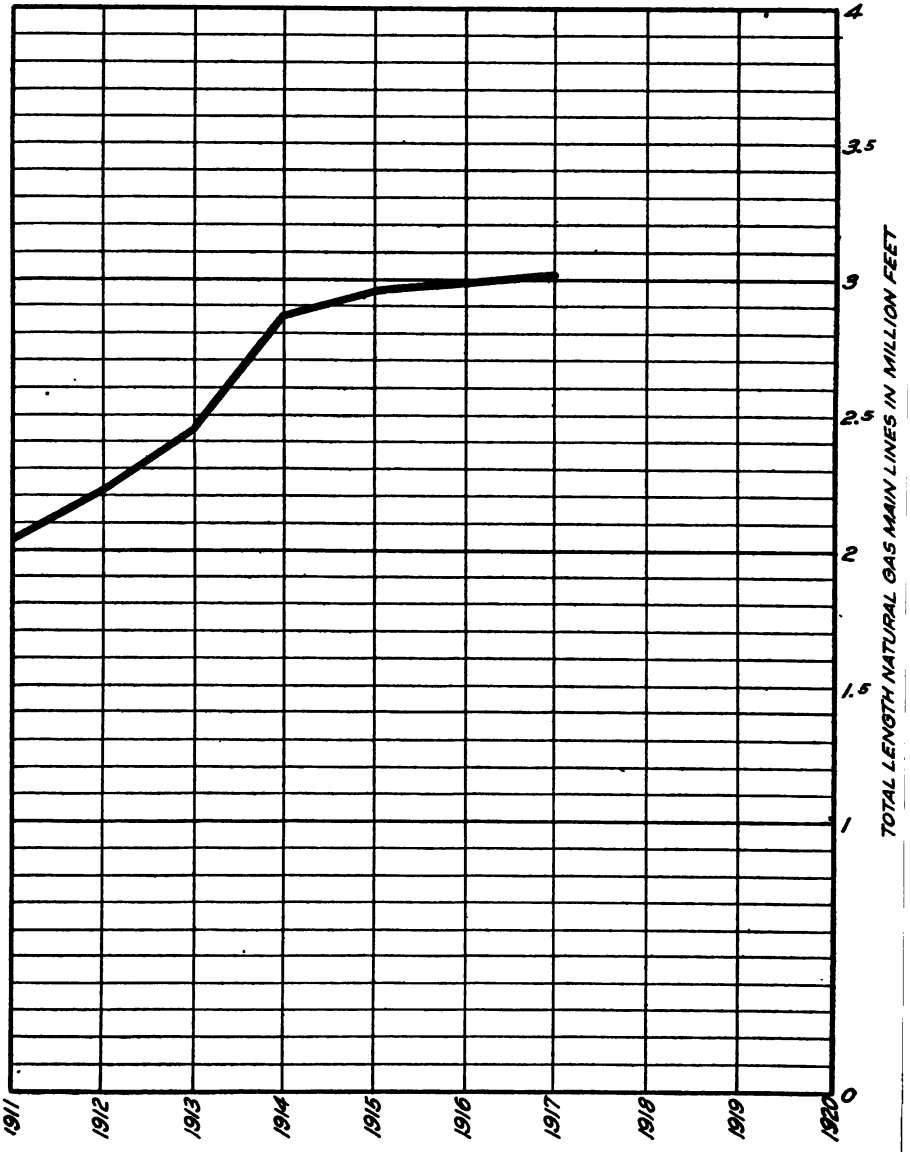

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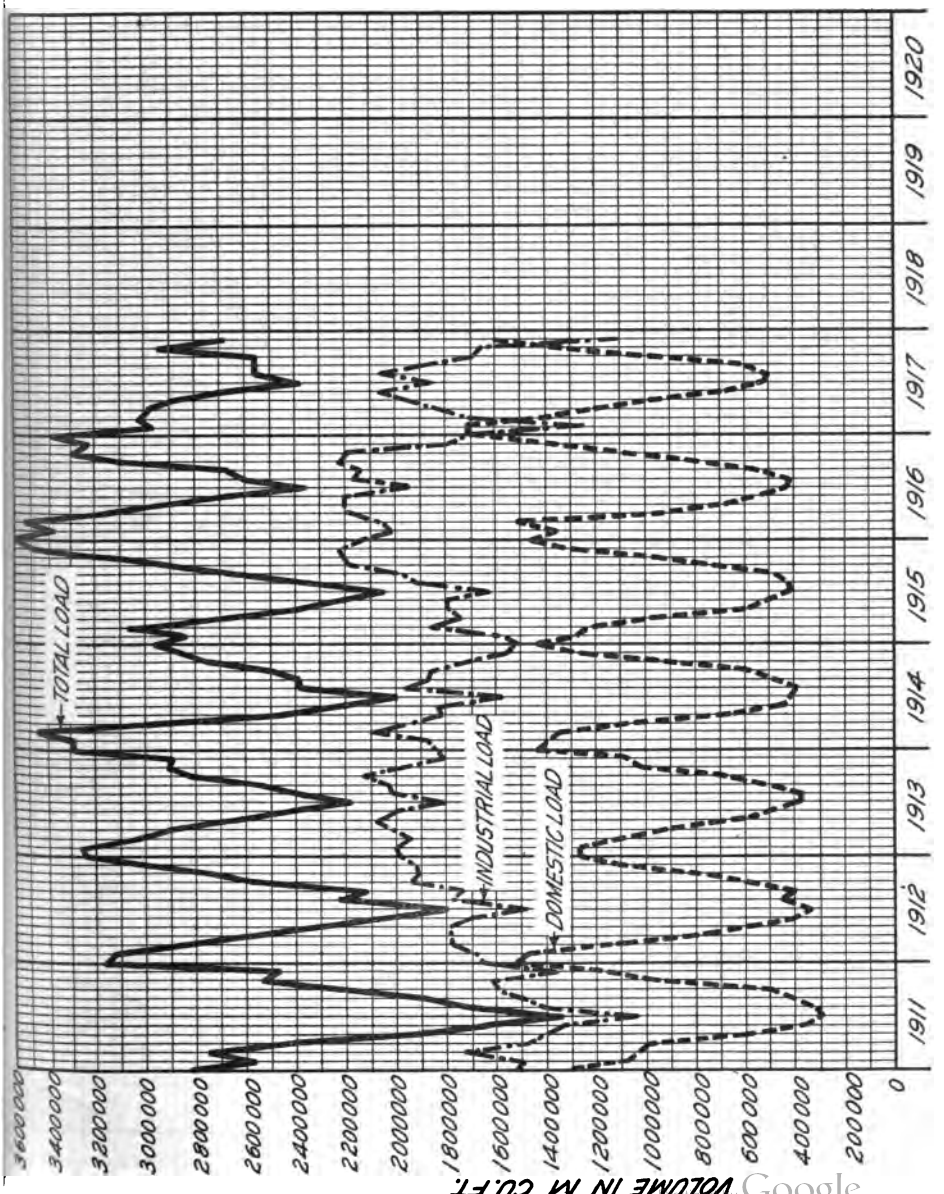
MONTHLY VARIATION
OF
DOMESTIC, INDUSTRIAL AND TOTAL NATURAL GAS LOAD
OF
THE MANUFACTURERS LIGHT & HEAT COMPANY

Note the marked peaks and seasonal variation in the domestic load.

The basic reasons for large sales of industrial gas are discussed on page 37 attached Smithsonian Bulletin.



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OF

THE PEOPLES NATURAL GAS COMPANY

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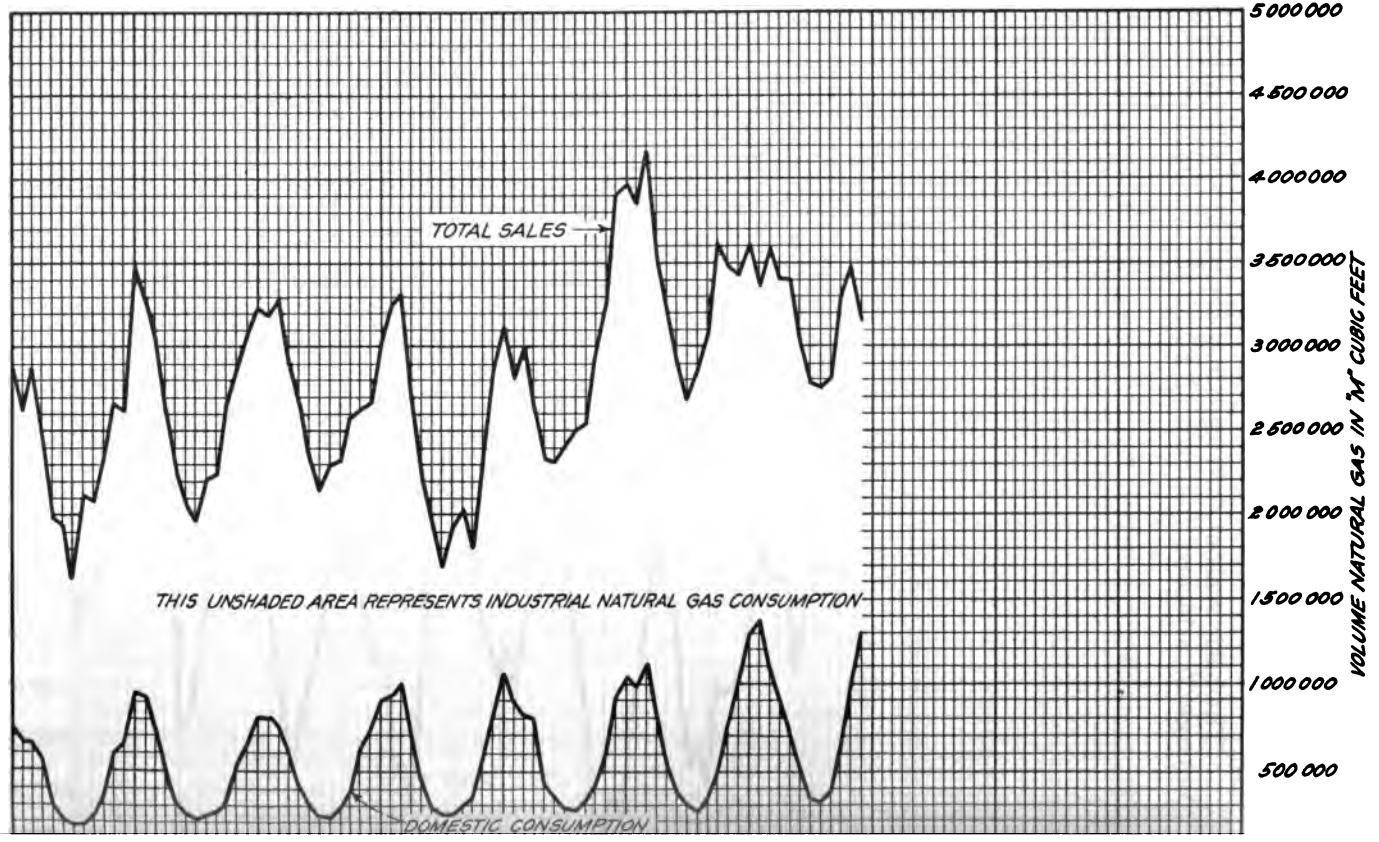

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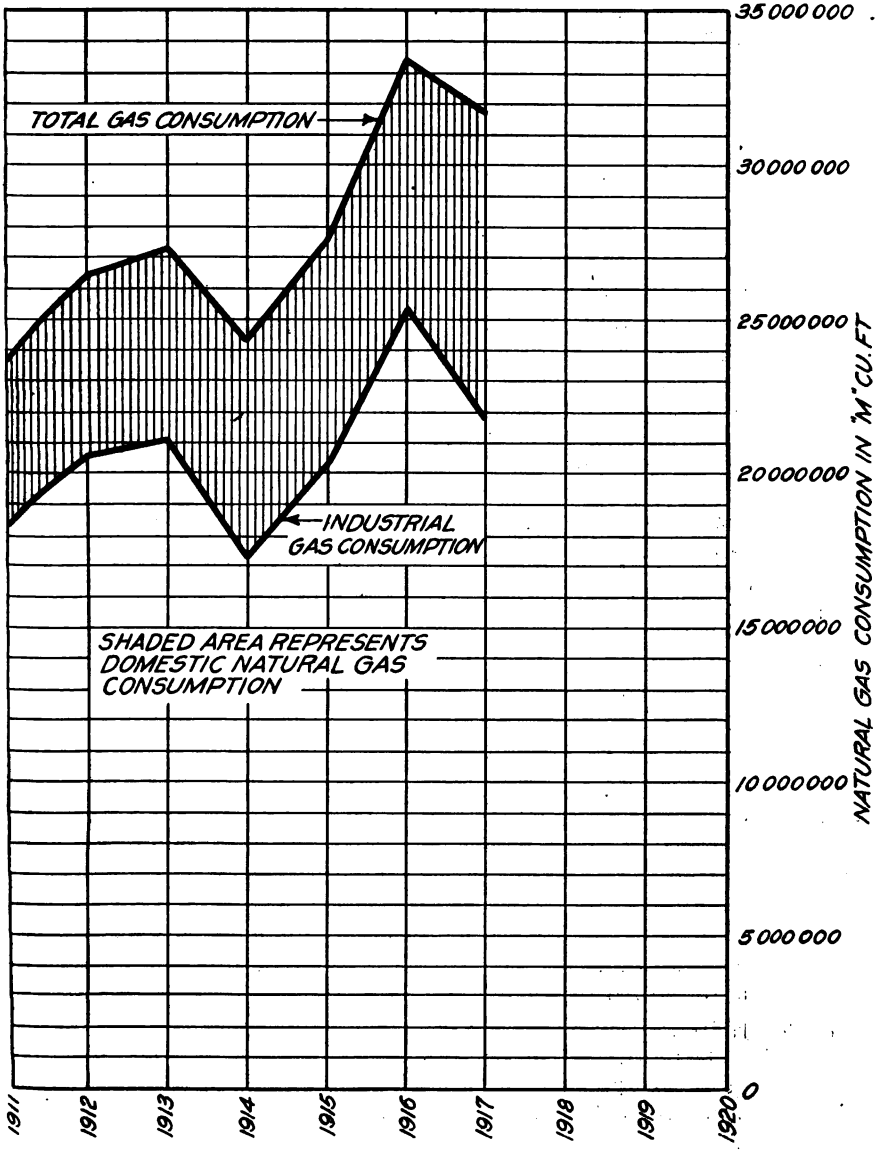
RELATION OF
DOMESTIC, INDUSTRIAL, AND TOTAL GAS CONSUMPTION
OF
THE PEOPLES NATURAL GAS COMPANY

The basic reasons for large sales of industrial gas are discussed on page 37 attached Smithsonian Bulletin.



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PART II

PROSPECTIVE NATURAL GAS SITUATION

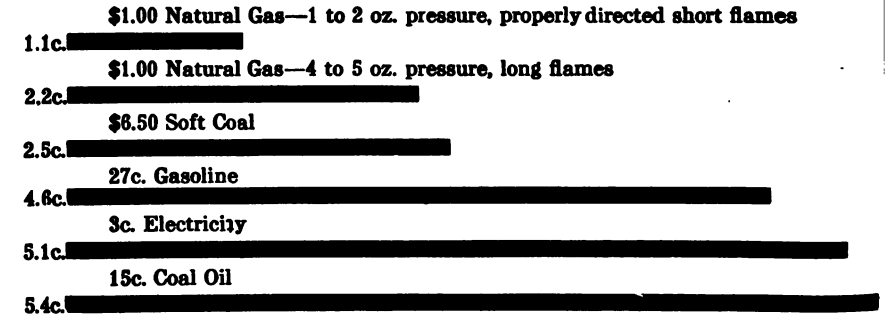
Sec. 5—What it will Cost to Replace Natural Gas

Natural gas is purer and has about twice the heating value of any manufactured gas that has been made. Man with all his skill has never been able to manufacture gas that is equal in quality to the natural gas which is now so generally wasted.

The natural gas distributed in Pennsylvania has twice the heating value of any manufactured gas that can be commercially made. The average price of new rates that have been made for manufactured gas is approximately $1.25 per "M" cu. ft. On this basis natural gas is worth $2.50 per "M" cu. ft.

Sec. 6—Natural Gas Compared with Other Fuels

In tests* made by the Department of Home Economics, Ohio State University, Columbus, Ohio, on "relative cost of five different fuels," it was found that $1.00 natural gas, when properly used, was by far the cheapest fuel. This relationship is shown in the diagram below, which represents the fuel cost of five different fuels each used for cooking a dinner consisting of thick or Swiss steak, escalloped potatoes, spinach, bread, butter, rice pudding, coffee, cream, sugar, with portions for six people.



Incidentally the above emphasizes the advantage to the consumer of using natural gas at low pressures with properly directed short flames as against higher pressures and long flames.

Sec. 7—Industry in Transition Stage

The natural gas industry is now in a critical period, and is in a transition stage going from a basis of large volume and low rates to lower volume and higher rates. This does not mean that the industry is on the road to destruc-

* Kitchen Tests of Relative Cost of natural gas, soft coal, coal oil, gasoline and electricity for Cooking—Made by the Department of Home Economics, The Ohio State University, Columbus, Ohio. Reprinted, October, 1918.

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tion; on the contrary the following of rational conservation policies will lengthen the life and stabilize the industry for future service.

For some towns it will be necessary to supplement the insufficient natural gas supplies with manufactured gas, distributing the two together as a mixed gas. In other towns it will be necessary to restrict the volume used by operating on practically a manufactured gas basis as far as volume and rate are concerned. That is, charge the equivalent of a manufactured gas price, but give the consumer the superior natural gas—as long as it is available—in this way giving the consumer twice the value for his money that he would receive if using manufactured gas.

In other communities, especially with large towns at the extreme ends of transmission lines, it may be necessary to abandon natural gas service entirely and remove the main transmission lines. In many of the smaller towns that are now served because of their contiguous or adjacent location to existing natural gas transmission lines —upon the removal of these main lines—it will generally not be feasible to handle manufactured gas in such small towns and they will probably be deprived of their gas service entirely. For further discussion see page 50 attached Smithsonian Bulletin.

On account of engineering limitations the possibility of distributing manufactured gas through existing main natural gas transmission lines is very much overestimated.

Sec. 8—Mutuality of Interest

The public, the domestic consumers and the gas companies are vitally and directly concerned in the conservation of the gas supply and the continuance of the service. If the supply is not conserved the public and companies will suffer, because the domestic consumer must go back to the more expensive manufactured gas, and much of the gas company property will have a salvage value only.

By intelligent co-operation between Public Service Commissions, the consumers, and the gas companies—on account of their joint interests—the supply of natural gas to consumers can be continued for many years and all interests be protected. It is, therefore, manifest that all of these interests should be willing to contribute to the conservation of the supply, the prevention of waste, and increase of production, and to this end make it profitable to the gas companies to invest their capital and extend their operations, which would ultimately benefit all three interests alike and be to the mutual advantage of all. This is further discussed on page 65 of attached Smithsonian Bulletin.

Sec. 9—What does the Term "Cost" Include?

Failure to recognize the distinction between "cost" and "price" has resulted in the selling of much natural gas at less than cost figures. "Price" is what the seller will take

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or the buyer will give for a given item of property, and may be more or less than cost.

The term "cost" embraces three distinct elements:

a. Expenditures made in operating plant.

b. Liabilities incurred in keeping property value intact. That is, so that the fixed capital entering into the enterprise will be intact, either in the form of tangible property, or a sinking fund when the enterprise stops. The frequent "ostrich attitude" of ignoring this will result in some rude awakenings in the future. Like interest, this is an accumulative factor that is always working and never at rest, thus constantly becoming larger as the inevitable day of reckoning is approached.

c. Rate of return on the property value used for rendering service commensurate with the hazards of the enterprise. The claim has frequently been made that return on capital is not a part of cost, but if the sale price on a particular transaction does not include this, then the transaction nets no return, and this deficiency must be made up on other transactions, thereby creating discrimination.

Sec. 10—Future Natural Gas Service Features

The dominating features of future natural gas service may be analyzed as follows:

a. **Gasoline should be removed**—The removal of the gasoline is desirable because it improves the quality of the service, as discussed on page 25 of attached Smithsonian Bulletin.

b. **Intensive and extensive use of compressors**—In order to get every foot of gas out of the ground that can be obtained, it will be desirable to use more compressing stations and operate existing stations at lower intake pressures. The writer believes that it would be very desirable to develop a self-contained automatic type of compressor that could be attached directly to individual wells, in order to more effectively remove the gas from certain isolated wells where it is not now commercially feasible to reduce the pressures low enough with existing compressing stations. Such a unit could be made automatic so as not to require attendance labor, and would be an effective conservation means. See also pages 28 and 29 attached Smithsonian Bulletin.

c. **Pooling of field operations desirable**—See pages 62 and 63 attached Smithsonian Bulletin.

d. **Gas must be measured**—All natural gas produced should be measured in the field, into and out of transmission lines and into distributing plants, so as to have a constant check on the leakage of the gas in transmission from the field to the ultimate consumer. Conservation of gas in natural gas transmission can be made effective only by the checking of dependable measuring data in order to determine the magnitude of transmission losses. See also page 54 attached Smithsonian Bulletin.

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e. **Electrolysis of pipes responsible for much waste**—The disintegrating action of stray electric currents that have leaked off of street railway tracks has caused much waste in the past and will be a formidable waste problem of the future. The pile of destroyed pipe shown on Plate 6 of the attached Smithsonian Bulletin is a good illustration of the destructive action of such stray currents.*

f. **Lower distributing pressures desirable**—See page 41 attached Smithsonian Bulletin.

g. **Gas must be used more efficiently**—The ordinary natural gas cooking stove now in use wastes about 85 per cent of the gas used. The ordinary coal furnace with gas burners in fire pot wastes about 75 per cent of the gas used. These wastes must obviously be corrected if gas conservation is to be made effective. See also page 40 attached Smithsonian Bulletin.

h. **Gas must be made worth saving**—

"The only wise way for the cities to do is to allow the gas companies sufficient price so that they can afford to prospect for, buy, and hold gas territory for the present and future use."

U. S. Bureau of Mines—Technical Paper No. 38, p. 28.

"As natural gas is the cleanest of fuels and is particularly adapted to household use, it does not seem unreasonable to consider it as strictly a domestic fuel and not a commercial one. It should be limited to the use where it will do the most good."

U. S. Bureau of Mines—Technical Paper No. 45, p. 50.

"The prices of natural gas for domestic consumption have generally been so low as not to provide, if only domestic sales were made, even sufficient income for overhead charges and operating expenses, so that in every case recourse has been had to large sales for industrial purposes to make up the deficiency. For these large sales which do not appreciably increase operating expenses, and do not require additional investment, and therefore do not increase overhead charges, the prices made have been relatively very low. Sometimes, of course, these sales have brought in large profits to the company, with the result that fields have been depleted in one-quarter or one-third of the time that they would have been under a different adjustment of rates and sales. Restricted use of natural gas for industrial purposes is of immeasurable benefit to a community, but unlimited and uneconomical use, because of cheapness, is a calamity for which every individual of the community will eventually have to pay."

U. S. Bureau of Mines—Dallas, Texas, Report—January, 1916.

See also pages 65 and 66 attached Smithsonian Bulletin. If the gas is made worth saving it will automatically result: first, in taking much more of the gas out of the ground; second, in transmitting the gas from the field to the consumer with a minimum of waste, and, third, in the consumer using the gas in an efficient manner.

* For further discussion see Digest of Publications of Bureau of Standards on Electrolysis of Underground Structures Caused by the Disintegrating Action of Stray Electric Currents from Electric Railways.

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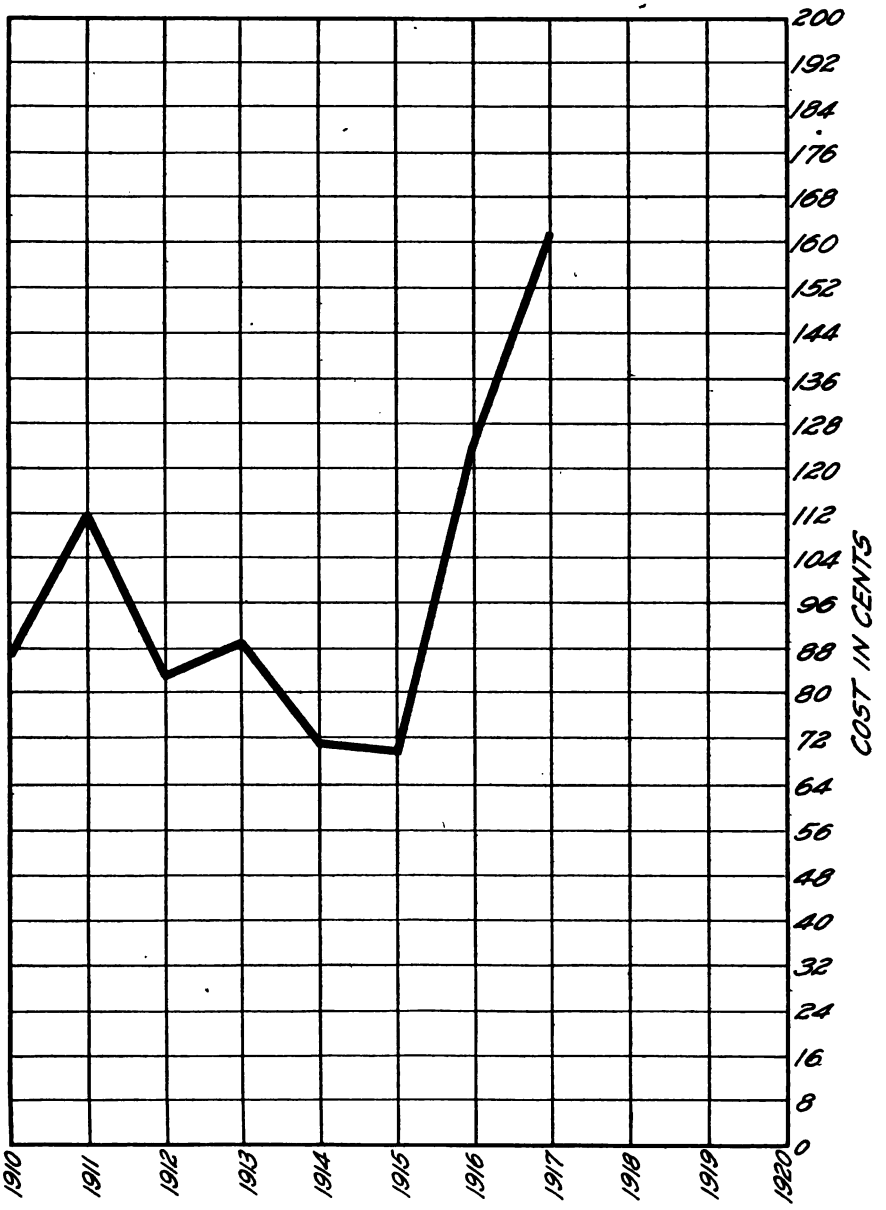
INCREASE IN
ANNUAL AVERAGE COST PER DOMESTIC CONSUMER
OF
OPERATING COMPRESSING STATIONS
OF
THE HOPE NATURAL GAS COMPANY



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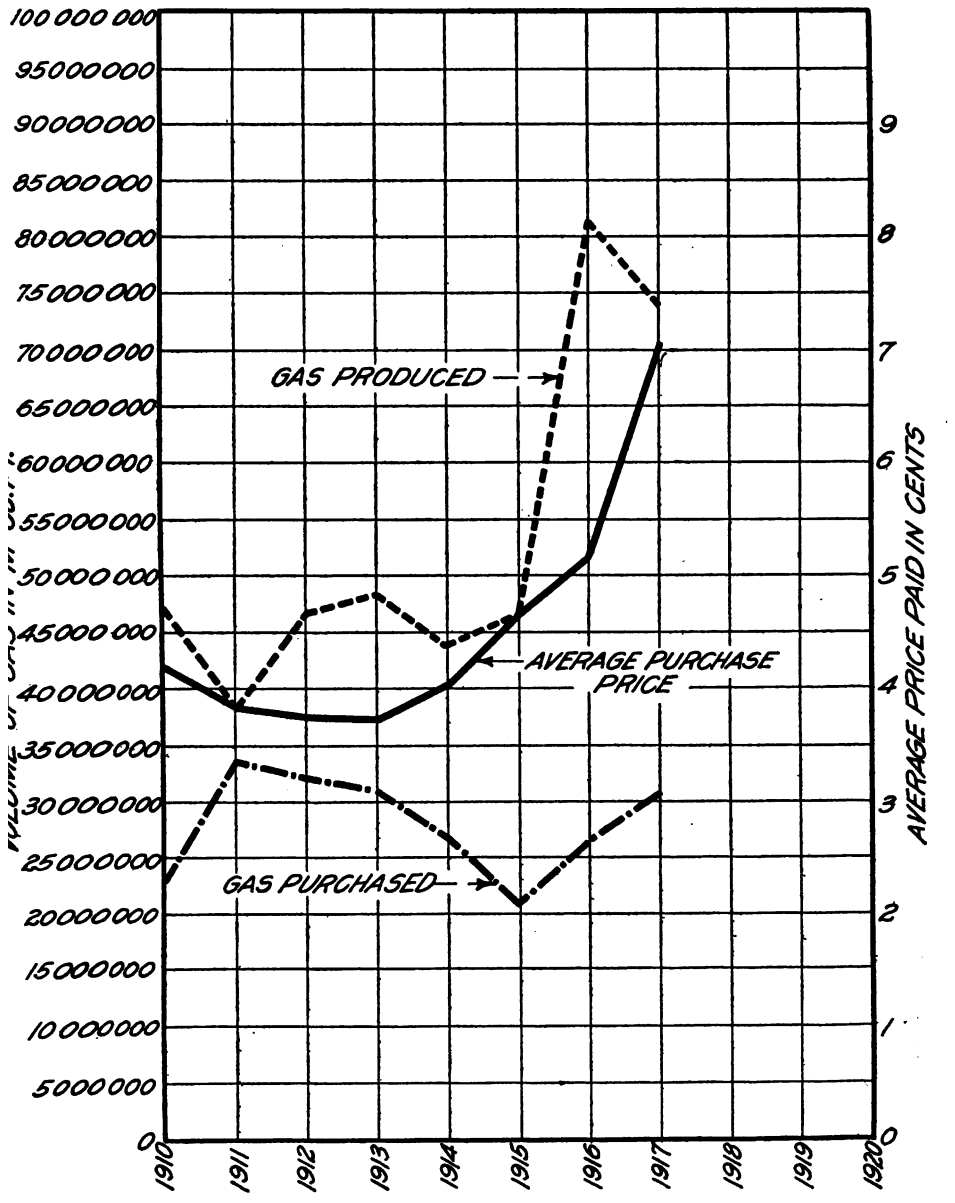
INCREASE IN
AVERAGE PURCHASE PRICE OF GAS PURCHASED
BY
THE HOPE NATURAL GAS COMPANY



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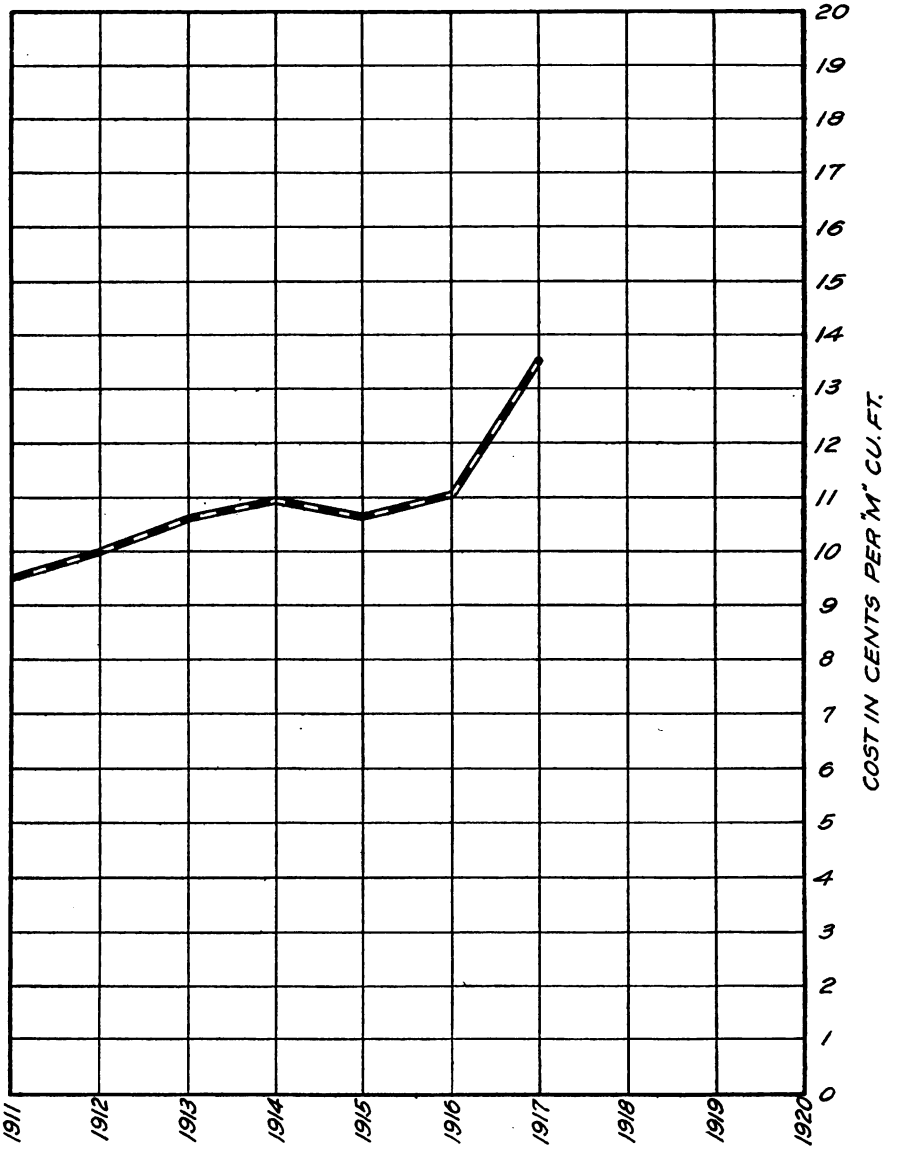
INCREASE IN
AVERAGE PURCHASE PRICE OF GAS PURCHASED
BY
THE PEOPLES NATURAL GAS COMPANY



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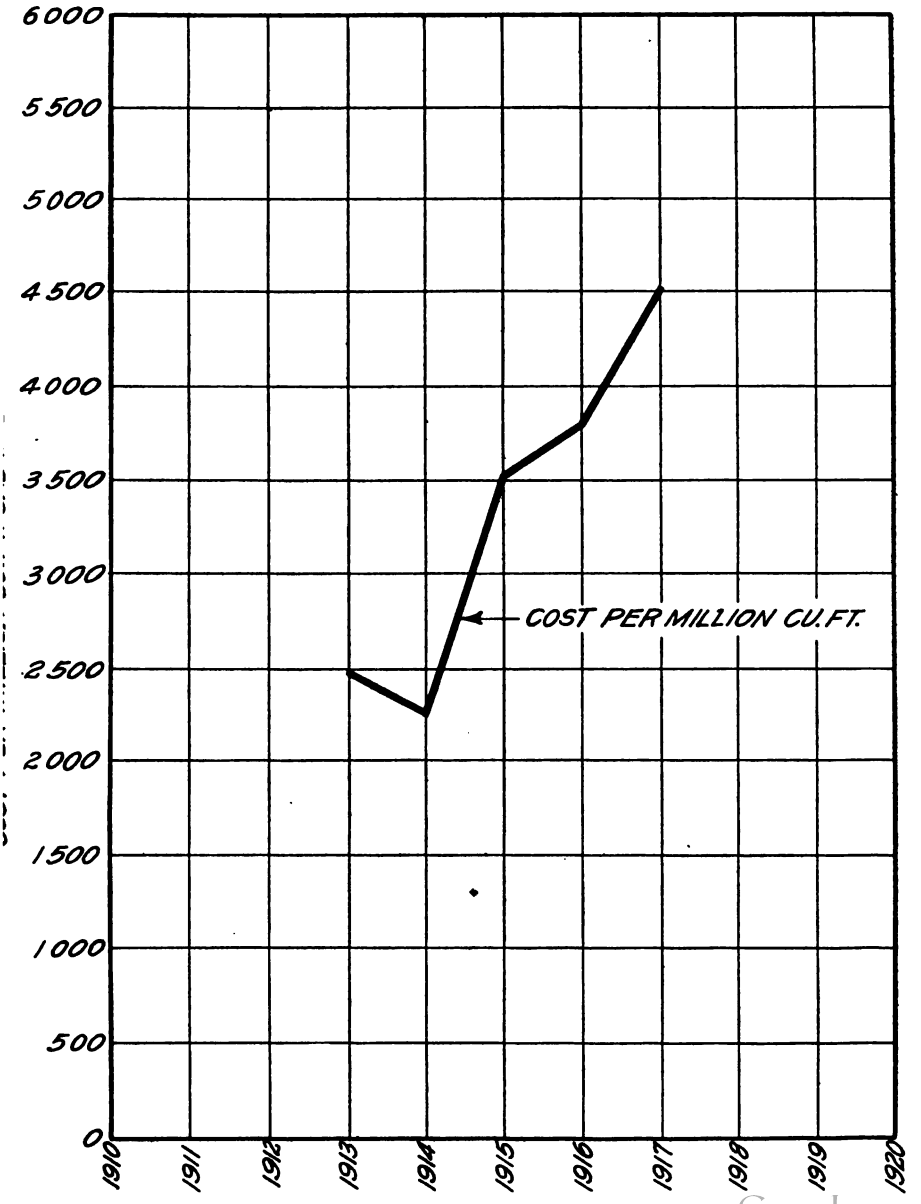
INCREASE IN COST PER MILLION CU. FT. OF OPEN FLOW CAPACITY OF NEW WELLS DRILLED BY THE HOPE NATURAL GAS COMPANY

This is brought about by the increased cost of drilling combined with the simultaneous decreased volume of gas obtained in new wells.



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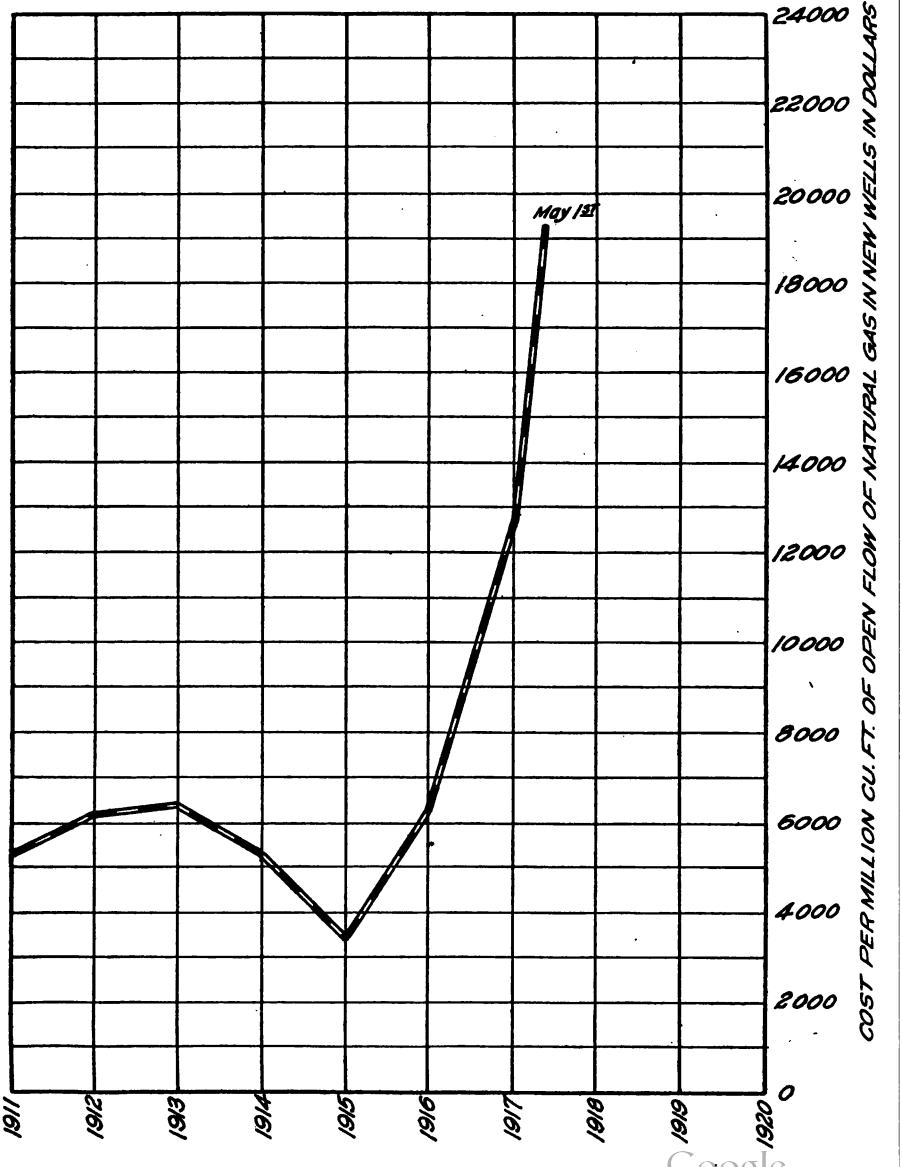

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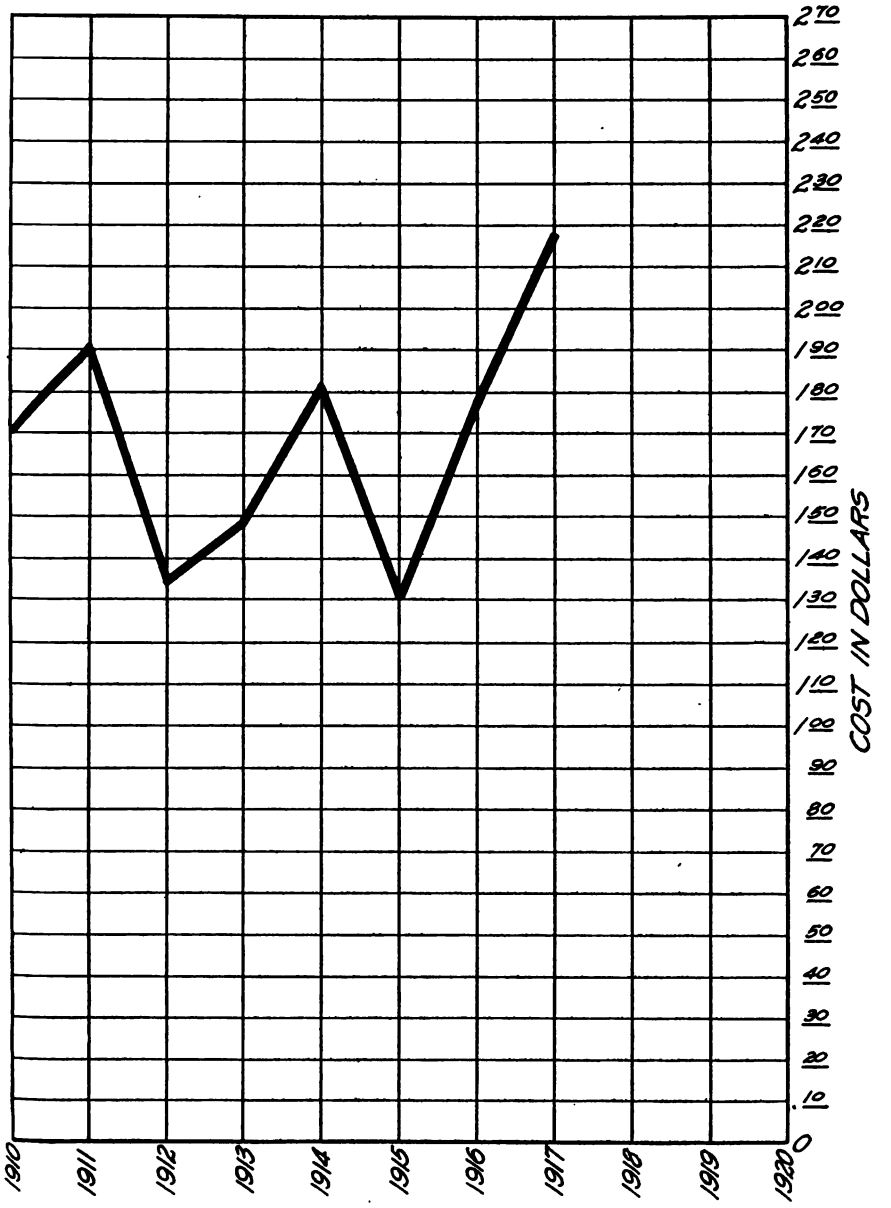
INCREASE IN
ANNUAL WELL OPERATING COST
PER DOMESTIC CONSUMER
OF
THE HOPE NATURAL GAS COMPANY



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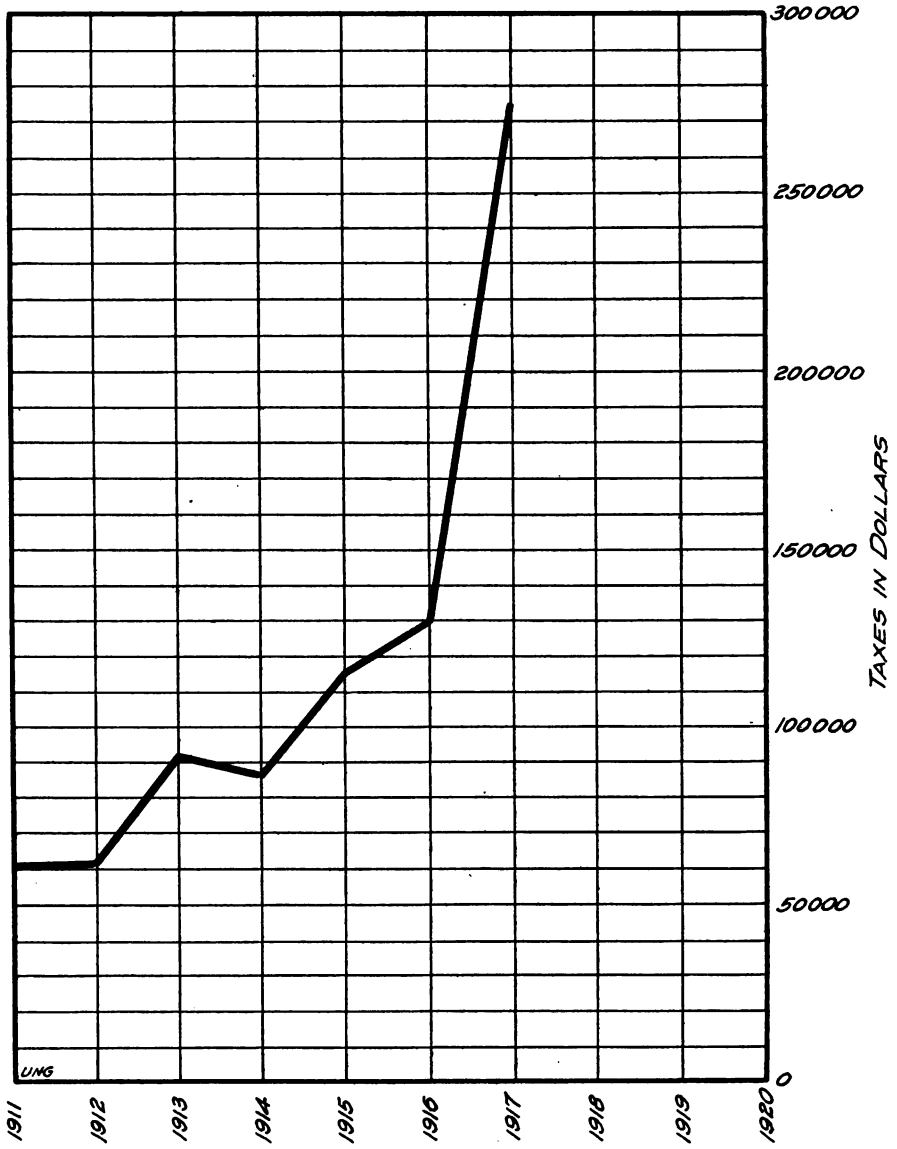
INCREASE IN TAXES
OF
THE UNITED NATURAL GAS COMPANY

Most people fail to appreciate that in the long run the public pays all forms of excise taxes levied on commodities or services purchased by the public.



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INCREASE IN TAXES

PER DOMESTIC CONSUMER

OF

THE PEOPLES NATURAL GAS COMPANY

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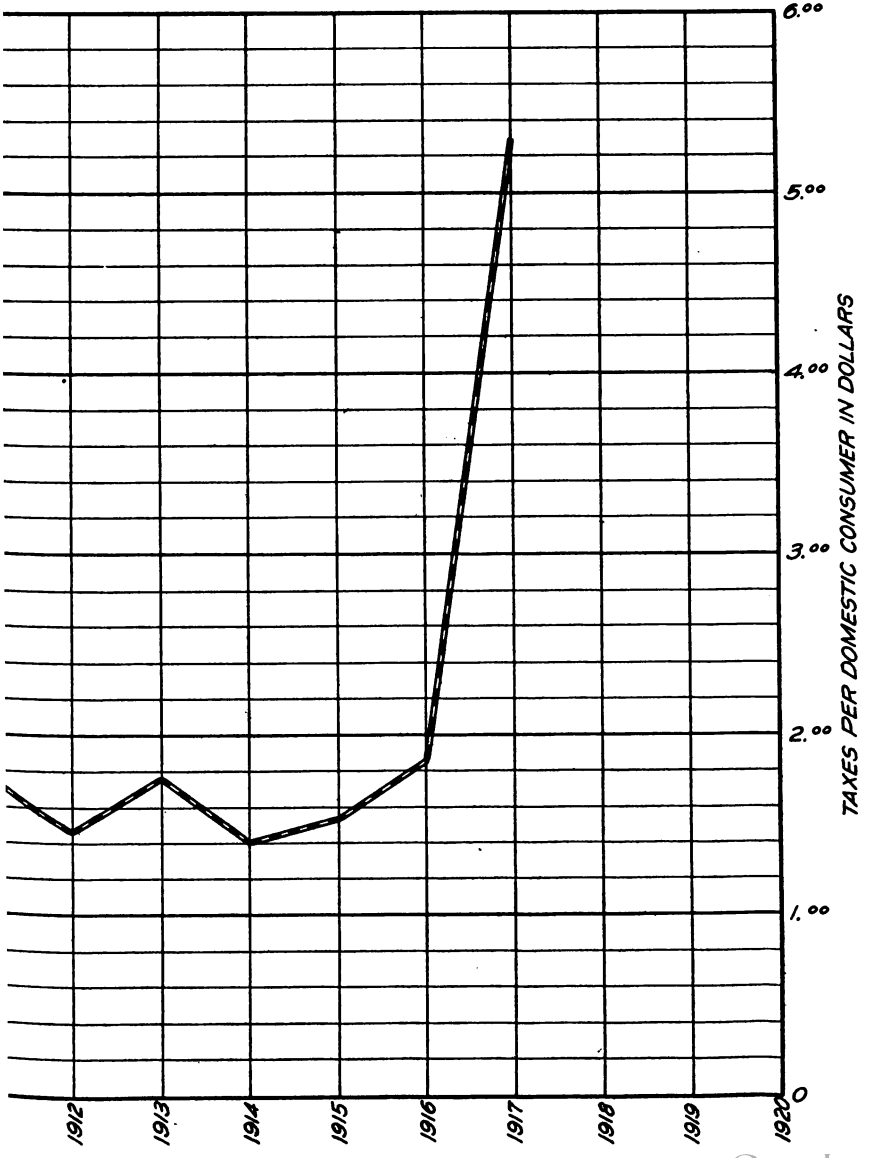

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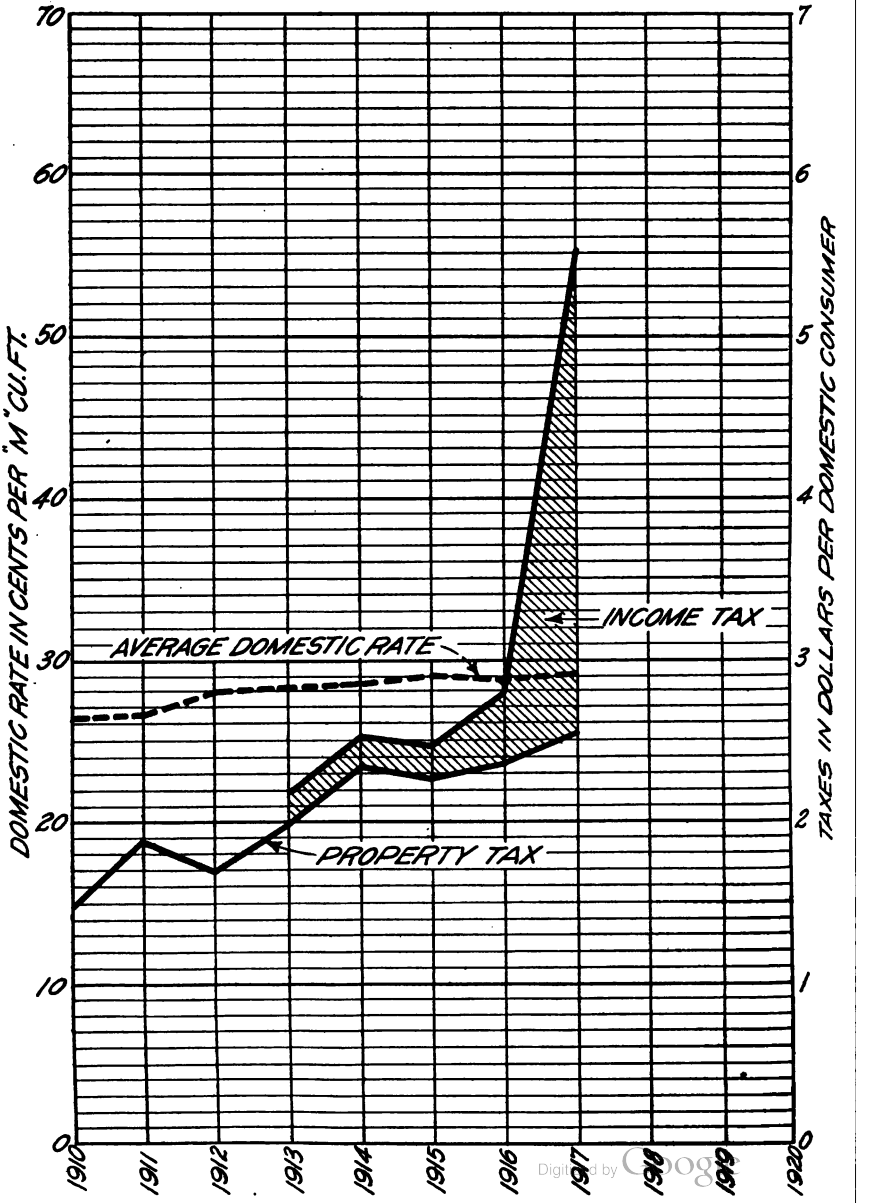
RELATION OF DOMESTIC NATURAL GAS RATES AND TAXES PER DOMESTIC CONSUMER OF THE MANUFACTURERS LIGHT & HEAT COMPANY

This shows that the taxes have increased much faster than the natural gas rates. Furthermore, the largest part of this increase is the income tax.

Most people fail to appreciate that in the long run the public pays all forms of excise taxes levied on commodities or services purchased by the public.



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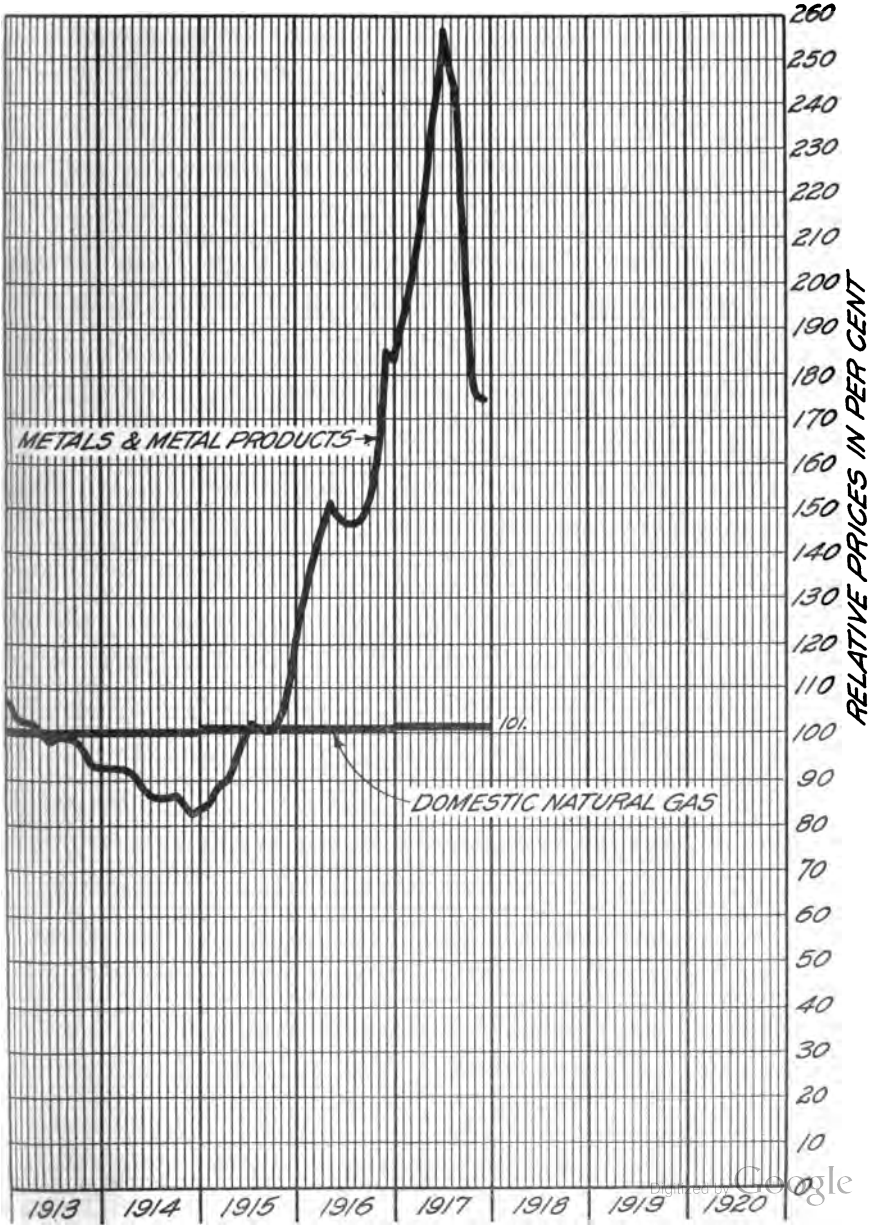
RELATIVE PRICES
WHOLESALE METALS AND METAL PRODUCTS
IN THE UNITED STATES AND
DOMESTIC NATURAL GAS
OF
THE HOPE NATURAL GAS COMPANY

The commodity prices are taken from page 106, Vol. 6—February, 1918—No. 2, Monthly Review of the U. S. Bureau of Labor Statistics. The maximum increase in domestic natural gas rates in these five years was 1% as contrasted with an increase of 158% in metals and metal products.



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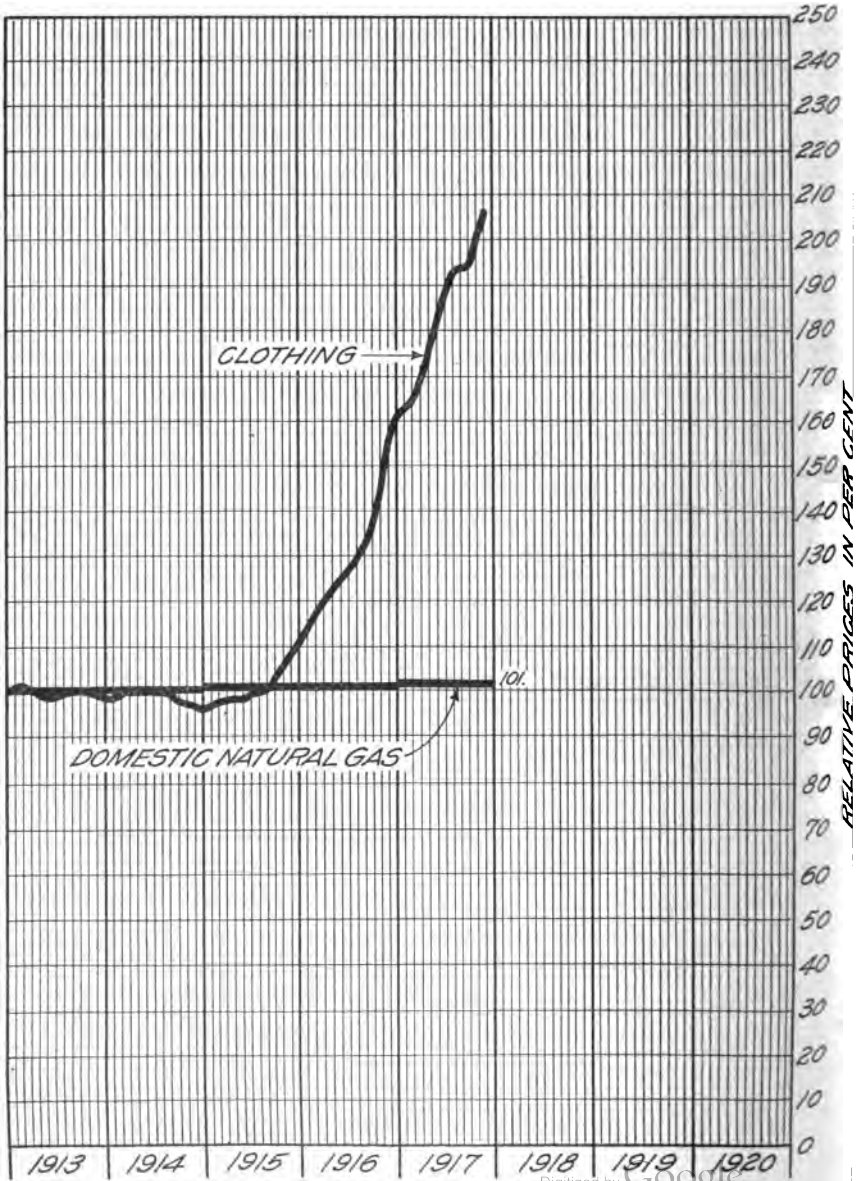
RELATIVE PRICES
WHOLESALE CLOTHING IN THE UNITED STATES
AND
DOMESTIC NATURAL GAS
OF
THE HOPE NATURAL GAS COMPANY

The commodity prices are taken from page 106, Vol. 6—February, 1918—No. 2 Monthly Review of the U. S. Bureau of Labor Statistics. The maximum increase in domestic natural gas rates in these five years was 1% as contrasted with an increase of 108% in clothing.



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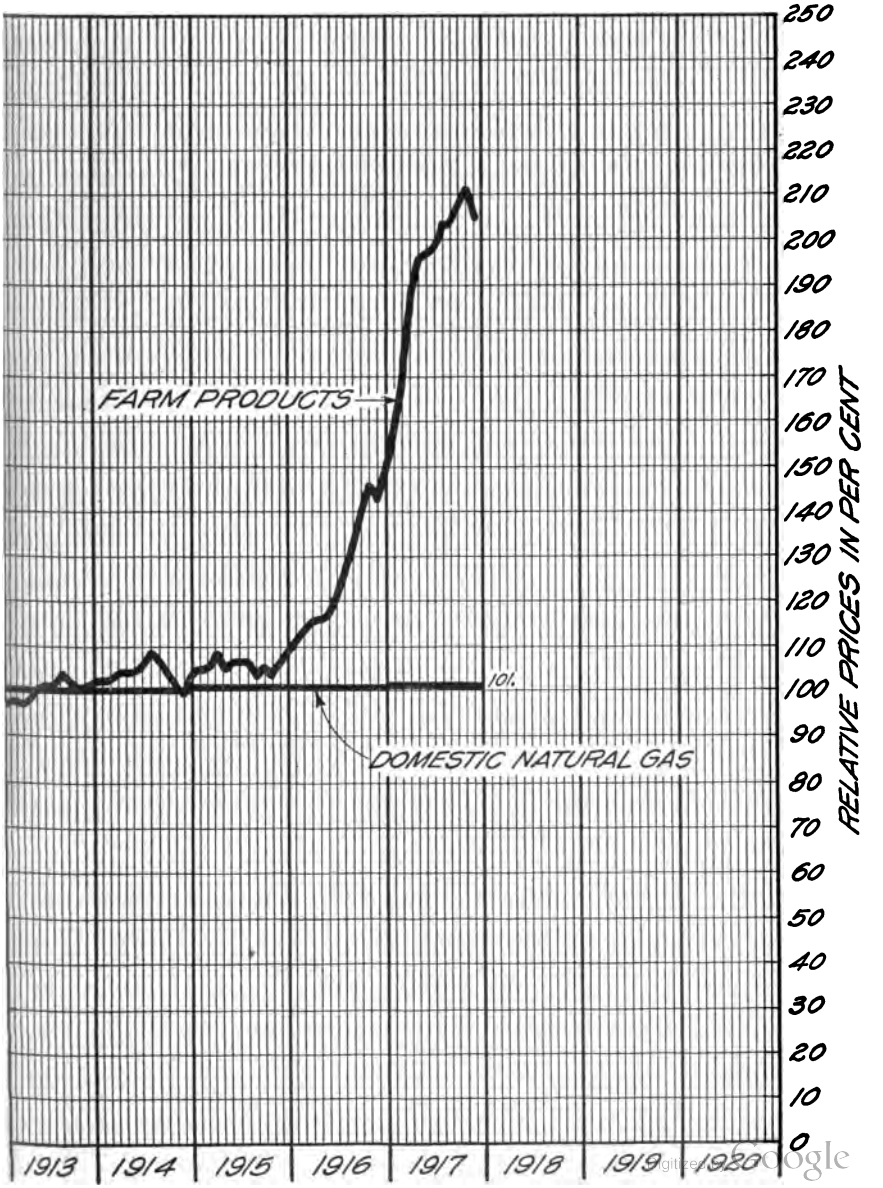
RELATIVE PRICES
WHOLESALE FARM PRODUCTS IN THE UNITED STATES
AND
DOMESTIC NATURAL GAS
OF
THE HOPE NATURAL GAS COMPANY

The commodity prices are taken from page 106, Vol. 6—February, 1918—No. 2 Monthly Review of the U. S. Bureau of Labor Statistics. The maximum increase in domestic natural gas rates in these five years was 1% as contrasted with an increase of 112% in farm products.



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SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 102, Part 7

THE MINERAL INDUSTRIES OF THE UNITED STATES

NATURAL GAS: ITS PRODUCTION, SERVICE, AND CONSERVATION

BY

SAMUEL S. WYER
Of Columbus, Ohio

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

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FOREWORD.

Natural gas is the least appreciated, consequently the most abused, of the mineral resources in popular use. The issues involved are of direct concern to some ten millions of the inhabitants of the United States, and their range of influence does not stop even here; for they form a prominent feature in the nation-wide problem of fuel supply which may be solved effectually only through coordinated attention to the component parts. This problem science and technology, working together, can take the initiative in simplifying, by pointing the way and devising means for its solution, but of their own initiative, they are powerless to go further. The responsibility of initiative in carrying forward the actual process of solution rests with the public, and resting with the public is contingent, as a first requisite, upon public opinion genuinely alive to the situation. This condition of affairs, naturally, is most pronounced in industrial connections of the public service order to which the activities comprising the natural gas industry belong; and this particular situation, bad enough from environment, is further aggravated by characteristics inherent in the resource.

The public must look to remedying the situation or within a very few years lose the services of the resource already seriously impaired. The stimulus to action contributed in the form of technical discussions is inadequate and equally so that afforded in appeals to sentiment and sensationalism. The United States National Museum has undertaken the preparation of an exhibit designed to visualize the situation in its true bearing, and the normal order of precedence would be to follow this with publications drawing upon the exhibit. In view of the present emergency, however, with its effect on the question of fuel supply, it is deemed best not to wait upon ceremony but to publish the present paper by Mr. S. S. Wyer, without the delay which would otherwise occur.

The situation is too complex for any simple formula of remedy. It is not only complex but acutely critical as well, and needs all the light that can be thrown on it from all sides. This particular discussion sets forth the technical issues as viewed by a practical engineer who alone is responsible for it in a concise, readable presentation which makes it a distinct contribution toward clarifying the situation.

C. G. GILBERT,
Curator, Division of Mineral Technology,
United States National Museum.

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NATURAL GAS: ITS PRODUCTION, SERVICE, AND CONSERVATION.

By SAMUEL S. WYER.
Of Columbus, Ohio.

FUNDAMENTAL PRINCIPLES OF NATURAL GAS PRODUCTION.

HOW NATURAL GAS IS MINED AND SERVED TO THE CONSUMER.

The first step is the securing of the lease or right to prospect for, reduce to possession, remove and market natural gas. This lease must usually be secured, held, and paid for, for a number of years—on the optimistic but unproven faith that it may contain gas—prior to beginning actual development work.

The unknown underground supplies of natural gas are found and reduced to possession by drilling down from the earth's surface. To protect the hole, an iron pipe—called a "casing"—is driven down into the rock formation always found above the gas-bearing sand rock. A plugging device known as a "packer" is fastened in the casing or hole in the rock, immediately above the gas formation, and the gas by virtue of its inherent expansive tendency then comes to the surface—usually about one-half mile above—through tubing, as shown on page 8, and forces itself into the transmission lines, when it then may continue by its own expansive force to travel on toward the consumer.

As the gas travels the pressure must drop, for the reasons given on page 10, and this necessitates the installation of gas compressors, whose function is to recompress the gas, increasing thereby its pressure, so that it will continue to travel through the transmission lines. From the compressing station the gas then goes to the consumer. When the gas reaches the distributing plant it passes into the medium pressure lines in the city and the pressure is then in turn reduced to the low-pressure lines, where it travels through the mains at probably 5-ounce pressure to the square inch—this, of course, constantly decreasing as the consumer's fixtures are approached—through the service cock, service line, consumer's meter, consumer's piping, and ultimately is burned at the consumer's fixtures.

These steps present an unbroken chain of service features, from the reserve acreage in the field—that must be carried and paid for in order to permit of future drilling operations, and, therefore, future service—to the consumer's fixtures, with this additional feature, that when the gas passes the consumer's meter it is reduced to possession

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by him, becomes his personal property, under his absolute control, and he can do with it what he pleases.

DEFINITION OF LEASE.

A natural gas lease is a contract for a consideration establishing a vested right to enter upon a definitely described parcel of land, for a determined period, to prospect for, reduce to possession, remove and market natural gas. The vested right is the crux of the whole matter, and it is immaterial whether the instrument creating it is called a "lease," "contract," "grant," or "deed of conveyance."

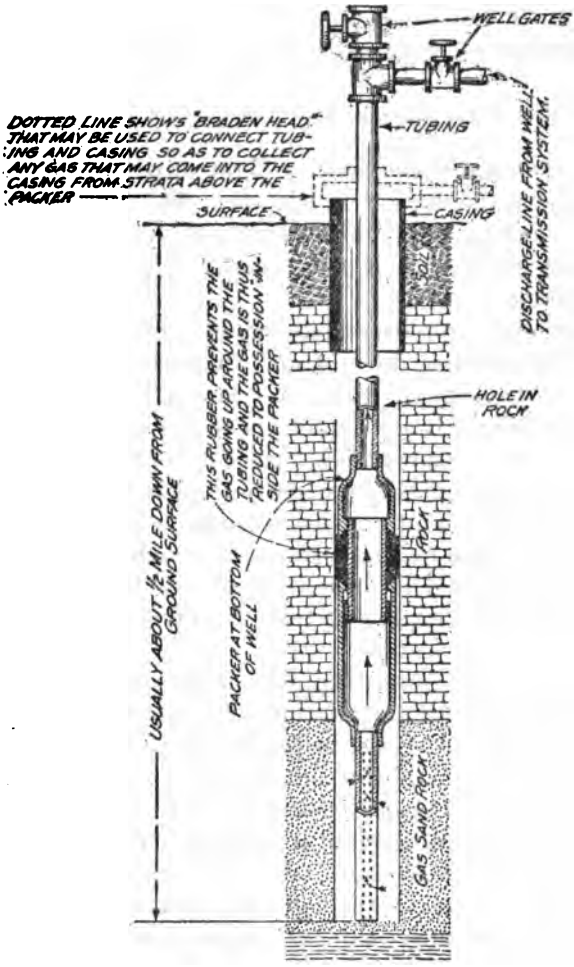
WELL GATES
TUBING
DOTTED LINE SHOWS "BRADEN HEAD" THAT MAY BE USED TO CONNECT TUBING AND CASING SO AS TO COLLECT ANY GAS THAT MAY COME INTO THE CASING FROM STRATA ABOVE THE PACKER
SURFACE
CASING
DISCHARGE LINE FROM WELL TO TRANSMISSION SYSTEM.
HOLE IN ROCK
THIS RUBBER PREVENTS THE GAS GOING UP AROUND THE TUBING AND THE GAS IS THUS REDUCED TO POSSESSION SIDE THE PACKER
USUALLY ABOUT ½ MILE DOWN FROM GROUND SURFACE
PACKER AT BOTTOM OF WELL
ROCK
ROCK
GAS SAND ROCK

FIG. 1.—DIAGRAM SHOWING HOW NATURAL GAS IS REDUCED TO POSSESSION.

In a given tract of land it is always a matter of doubt to what extent, if any, mineral may exist in paying quantities, until very considerable development work has been performed, which requires in most instances large expenditure of capital. For this and other reasons, a custom long ago arose for the owner of supposed mineral land to grant to a mine operator the right to enter upon the land and search for and extract mineral, and the form which the contracting parties pretty generally adopted to express their agreement was a "lease," which purported to entitle the "lessee" to occupy such part of the premises as was necessary to carry on his mining operations, and to use, mine, and extract the minerals therefrom. (Lindley on Mines, ed. 3, p. 2134.)

RESERVE ACREAGE.

Based on the United States Geological Survey statistics for 1916, natural gas producers in this country carry an average of 313 acres

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for each producing well, in their attempt to provide as far as possible continuity of service to their customers. However, this average of 313 acres will vary with different fields and localities. In West Virginia the United Fuel Gas Co. in 1917 carried 1,252 acres to the producing well, as shown on page 24. From this it is evident that not every farmer—that is, landowner—can have a producing well, even though his farm may be located in the center of producing territory. While natural gas wells are frequently drilled on tracts of less than an acre in area, by small producers intent only on getting the gas out in the fastest possible manner, without any regard to future service, the future continuity of service to the gas-using public is possible only by the carrying of reserve acreage for future drilling operations.

DISTINCTION BETWEEN ACREAGE LEASE RENTALS AND GAS WELL ROYALTIES.

The general custom of the natural gas business is to pay a lease rental based either directly on indirectly on the acreage of the tract that is controlled. The natural gas acreage statistics of the United States Geological Survey for 1916 show that—

5 per cent of acreage is owned in fee.
8 per cent of gas rights are owned in fee.
87 per cent of gas rights are merely under lease.

This acreage rental covers a twofold object—

1. Gives the gas company the right to enter the particular tract of land for exploration purposes.

2. Pays the farmer—that is, landowner—for any gas that might be found on such tract, even though such gas would be removed by drainage through to wells located on adjacent tracts.

Well royalty is merely compensation for particular wells drilled, and replaces the acreage rental that prevailed prior to the drilling of the wells. The well royalty for a particular tract is usually larger than the aggregate of the acreage rental because of the damages and inconvenience to the farmer in having wells and their appurtenances located in his fields.

It is not ordinarily appreciated that the total amount of money paid for "acreage rental" is larger than for "well royalties." Thus, the acreage rental of the United Fuel Gas Co. for the year 1917 was 80 per cent of the total annual sum spent for gas rights.

FUNDAMENTAL CONCEPTION OF GAS.

Gas is a fluid composed of a large number of molecules which are vehicles of energy continually in motion and having an inherent tendency to get farther and farther apart. The range of motion

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of the molecules is limited only by the volume of the closed containing vessel in which they constantly move to and fro. Every molecule possesses the inherent power of energy and is eternally energetic within itself. That is, the molecules are in a state of constant bombardment against each other and against the sides of the containing vessel. The most distinguishing characteristic of gas is its universal property of completely filling an inclosed space.

CAUSE OF GAS PRESSURE.

Gas pressure is the result of the combined efforts of all the moving molecules in the gas trying to get farther and farther apart; that is, a mass of gas inclosed in a vessel expands and fills it, and, being restrained from further expansion, it exercises a pressure against the walls of the vessel. This pressure is the same in all directions on equal areas of surface. Not only is every gas molecule eternally energetic but its energy may be augumented or retarded by external conditions. Contracting the volume of gas increases the intensity of its internal molecular motion and therefore increases its pressure. Conversely, expanding the volume of a given mass of gas decreases the intensity of its internal molecular motion and therefore decreases its pressure. That is, with a given mass of gas any increase in volume of containing vessel will give the molecules more range of motion and thereby lower the pressure. Thus, if a part of a given mass of gas is removed from a closed vessel or reservoir the remaining mass of gas will expand instanter and keep the vessel or reservoir filled, but at a lower pressure.

WHAT MAKES GAS FLOW.

The inherent tendency of gas to expand is the basic cause of gas flow. Gas flow in pipes or underground reservoirs can not take place except between openings of higher, to openings of lower pressure; that is, flow can be obtained only by sacrificing pressure. This is in accordance with the universal natural law that as long as energy of any form undergoes no transformation it tends to gravitate to a lower degree of intensity—that is, becomes more stable and approaches a universal level of stable equilibrium. Thus, water always seeks the lowest level, and confined gas always tends to expand to lower pressures. Even where gas compressors are used to increase the pressure by contracing the volume, the gas is not pushed through the pipe like a plug of incompressible fluid, like oil or water, but goes through by virtue of the increased expansive force resulting from the higher pressure.

DEFINITION OF NATURAL GAS.

Natural gas is a highly combustible gas made by a secret process of nature. It is not a chemical compound—as popularly supposed—

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but a mechanical mixture of several combustible and diluent gases and vapors thoroughly diffused through each other, the number and exact proportion of the various crude natural constituents varying for the different localities and somewhat during the working lives of individual wells.

The term "casing-head gas" is applied to a natural gas that flows from oil wells, coming out between the casing and tubing. It is collected by means of a metal head—called "braden-head"[1]—connecting the casing with the tubing, as shown by the dotted lines at the top of fig. 1. The term "braden-head gas" is sometimes used synonymously for casing-head gas.

DEFINITION OF "MECHANICAL MIXTURE."

This is a mixture where two or more substances are brought together in a thoroughly commingled state, without, however, any of the constituent substances losing their individual identity. The various vapors and gases going to make up natural gas are merely intermingled as mechanical mixtures. Another very common illustration is atmospheric air, where water vapor and the gases oxygen and nitrogen are merely mixed in the form of a mechanical mixture; that is, the water vapor has undergone no chemical change and the oxygen and nitrogen have undergone no chemical change by the mixture.

DEFINITION OF TERM "VAPOR."

This word literally means a warm exhalation. A vapor is the gaseous state of a substance which at ordinary temperature exists as a solid or liquid; that is, the vapor is the result of the action of heat on a solid or liquid. On removal of the heat the vapor will return to its former solid or liquid state. When a liquid, by the action of heat, goes into a vapor or gaseous form it is said to vaporize or evaporate, the meaning of these two terms being the same. The most common form of vapor is the moisture always present in greater or less degree in the atmospheric air.

GASES AND VAPORS DISTINGUISHED.

A vapor is an aeriform substance in the gaseous state at any temperature below the critical point, the critical point being the line of demarcation between a vapor and a gas. The temperature of fluid at the critical point is the critical temperature, and the pressure which at this critical temperature just suffices to condense the gas to the liquid form is called the critical pressure. A vapor can be reduced to a liquid by pressure alone, and may exist as a saturated

[1] Named after its designer Mr. Glenn T. Braden.

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vapor in the presence of its own liquid. A gas is the form which any liquid assumes above its critical temperature, and it can not be liquefied by pressure alone, but only by its combined pressure and cooling. All vapors are gases, but not all gases are vapors. The difference between vapors and gases may be summarized as follows:

Aeriform fluids.

Vapor.	Gas.
Below its critical temperature and pressure.	Above its critical temperature.
Can be condensed by pressure alone.	Can be condensed only by both pressure and cold.

Gasoline found in natural gas always exists there in the form of a vapor, while methane, for instance, in natural gas exists only as a gas.

NATURAL GAS MAY BE WET OR DRY.

Natural gases coming from the ground may be classed—according to their gasoline vapor content—into two main groups, namely:

1. *Wet gas.*—This is gas intimately associated with oil, usually produced with oil, and is ordinarily known as casing head natural gas.

2. *Dry gas.*—This is gas not intimately associated with oil, but may nevertheless contain gasoline vapors. The term "dry" does not refer to water vapor that may be carried by the gas, but rather to the gasoline vapor, and, furthermore, this is a relative term since a strictly dry gas would be one containing no gasoline vapors.[1]

WRONG IMPRESSION OF WORD "NATURAL."

While natural gas is a natural product made by nature, it is no more natural than other minerals, like coal, oil, or iron ore. The word "natural" came into common use probably as contrasted with manufactured gas, and the use of the word appears to have given a fallacious impression that natural gas was a free and unlimited resource. Merely being made by nature does not mean that a substance is cheap and of low value. Natural gas is a natural resource, which men have learned to use for the satisfaction of their wants. The misconception regarding the position of natural gas has arisen from failing to appreciate that man creates no new matter and can merely get the materials of nature ready for consumption. Food, clothing, wealth in all its forms, are derived originally from nature. The forces of nature, working through the ages, have created things which mankind needs. Human effort expended on these products of nature, converts them into forms which are usable.[2]

[1] For further discussion, see Bureau of Mines Bulletins No. 88 and No. 120.
[2] Suggested by Ely's Outlines of Economics.

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NATURAL GAS A MINERAL.

Broadly, the word mineral means the inorganic materials of which the earth consists. "The word minerals in the popular sense means those inorganic constituents of the earth's crust which are commonly obtained by mining or other process for bringing them to the surface for profit." That is, the term "mineral" is not, *per se*, a term of art or trade, but of general language, and in addition to its broad scientific meaning is also used in a commercial sense where it may include any inorganic substances found in nature, having sufficient value, separated from its condition as a part of the earth, to be mined.

Natural gas is now universally classed as a mineral. However, on account of its adventitious origin, migratory habits, and fugitive tendencies, it is regarded as a mineral with special attributes. Since it is a mineral, it is, therefore, a crude product. As so aptly stated by the United States Supreme Court, "Natural gas is a crude mineral, not advanced in value or condition by refining or grinding or by any other process of manufacture." [1]

ORIGIN OR FORMATION OF NATURAL GAS.

How, when, and where the constituents of natural gas were formed is not definitely known. For our purpose we need not bother about the various theories that have been propounded regarding the origin or formation of petroleum generally or natural gas constituents in particular. That is, whether these constituents originated from cosmic, organic, inorganic, animal, vegetable, volcanic, animal bacterial, plant bacterial, diatomic, or fatty algal sources is not germane. Neither is the matter of adventitious and migratory or indigenous and accumulative relationship with regard to any geological formation of vital importance.

The incontrovertible facts are that we have in natural gas a crude natural substance made up of mixtures of widely varying constituents—even though we may not know how these mixtures were thrown together—for different natural gas fields in the United States. Some of these natural gases are wet, while others are dry; some are high in heating value, while others are low, and some are heavy, while others are light in weight.

STARTING POINT OF GAS ACTIVITY.

As far as temperature is concerned, gas activity begins at a point 460° below zero on the Fahrenheit scale, and as far as pressure is concerned, it begins at the point of absolute vacuum, or 14.7 pounds below atmospheric pressure at sea level. Neither point has ever

[1] United States *versus* Buffalo Natural Gas Fuel Co., 172 U. S., p. 339.

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been reached by man's physical senses, but both form the bases from which all gas volume calculations must be made as shown on pages 15 and 16.

BAROMETRIC PRESSURE.

Atmospheric pressure is measured by a barometer—usually in inches of mercury, 1 inch of mercury equaling 0.49 pound to the square inch pressure—and is synonymous with barometric pressure.

Sea level is the basis from which atmospheric pressures are reckoned. At that point dry air at 32° Fahrenheit exerts a pressure of 14.7 pounds to the square inch.

This pressure varies with altitude and temperature, the pressure decreasing with an increase in altitude or temperature. 14.4 pounds represents a fair average barometric pressure for most natural gas using communities.

GAGE PRESSURE.

This is simply the pressure indicated by a pressure gage. Two general classes of gages are used for measuring gas pressure:

1. *Spring gages.*—Where the effect of the pressure exerted against some form of spring is made to move a pointer over a graduated dial or scale.

2. *Fluid gages.*—Where the effect of the pressure is indicated by the height of the column of fluid in a U-shaped tube. One side of the U-shaped tube is open to the atmosphere and the other is attached to the pipe where the pressure is to be measured. The gas pressure in this pipe then lowers the fluid in one side of the tube and raises it in the other. The total difference in the heights of the fluid on the two sides represents the total fluid pressures. When no pressure is applied to such a U tube gage other than the prevailing atmospheric pressure, the liquid will stand at the same level in both tubes.

The pressures in natural gas distributing plants are almost universally measured in ounces to the square inch, while the pressures in manufactured gas distributing plants are measured in inches of water, 1 ounce equaling 1.73 inches of water.

Where the word pressure occurs in ordinances or rules it invariably means gage pressure.

ABSOLUTE PRESSURE.

This is the sum of the gage pressure and the barometric pressure. Thus, if the gage pressure is 4 ounces—equaling 0.25 pound—and the atmospheric pressure 14.4 pounds to the square inch, the absolute pressure will be 14.65 pounds to the square inch, as shown on p. 15. This must be used in all gas calculations dealing with change of volume due to effect of pressure.

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Failure to appreciate that the absolute pressure, rather than merely the gage pressure, must be used when computing the effect of pressure on gas volume, or heating value content, has been responsible for most of the misunderstanding regarding the effect of variation in gage pressure on gas quality and gas service.

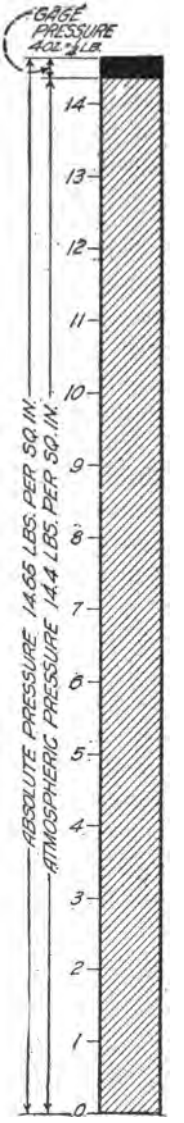

FIG. 2. — DIAGRAM SHOWING RELATION OF ATMOSPHERIC AND GAGE PRESSURE.

DIFFERENTIAL PRESSURE.

This is simply the difference between the pressure at the inlet and outlet of a gas line. Thus, if the inlet gage pressure of a gas line were 50 pounds and the outlet gage pressure 10 pounds the differential pressure would be 40 pounds. In gas transmission it is necessary to have a differential pressure in order to secure driving power to force the gas through the line. That is, the differential pressure is the pressure that is lost in overcoming the friction of the gas moving through the line.

EFFECT OF PRESSURE ON GAS VOLUME, KNOWN AS BOYLE'S LAW.

There is a definite relationship existing between the volume and pressure of natural gas. That is, when the gas is compressed or allowed to expand, it approximately follows Boyle's law. This law may be stated as follows: "The volume of a gas at constant temperature varies inversely as the absolute pressure to which the gas is subjected; or, what is the same thing, the product of the absolute pressure and the volume of a given quantity of gas remains constant."

Thus, if the volume is doubled, or one-half of the gas is removed from a fixed reservoir, the absolute pressure will be reduced one-half. Conversely, if the absolute rock pressure in a fixed reservoir is reduced to one-half, the volume of gas remaining compressed in that reservoir will be reduced to one-half.

It has been the universal custom of the natural gas industry to disregard the small deviation of natural gas from Boyle's law and in measuring computations to assume that the gas follows the law exactly. Tests made on the West Virginia gas indicate that the per cent of deviation increases with the pressure. That is, while there is no perceptible deviation at pressures under 15 pounds, at 150 pounds the deviation would be about 6 per cent. That is, the

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actual expansion of gas in lowering the pressure from 150 pounds down to less than 10 pounds would be about 6 per cent greater than that given by literal application of the law. This has the practical effect of making leakage in main lines and natural gas distributing plants sometimes seem considerably less than it actually is, due to failure to recognize that in expanding from high pressure to low the gas actually increases in volume more than the exact literal application of the law would give.[1]

EFFECT OF TEMPERATURE ON GAS VOLUME, KNOWN AS CHARLES' LAW.

"The volume of a given mass of any gas under constant pressure increases from the freezing point by a constant fraction of its volume at zero." This starts from the absolute zero of the gas, which is 492° F. below freezing, as shown at the right. In other words, the gas will expand 1/492 of its volume at 32° F. for each degree Fahrenheit rise of temperature.

This makes the change in volume directly proportional to the absolute temperature and means that approximately each 5° F. increase in temperatures makes an increase of 1 per cent in volume and each 5° F. decrease in temperature makes a decrease of 1 per cent in volume. For specific application of this see page 471.

GAS SAND OR GAS ROCK.

In no case is the gas found in rooms, caverns, or large crevices, as popularly supposed. "The oil and gas sands are simply very porous rocks which contain not only one great cavity, but millions upon millions of small or microscopic cavities, so that the oil, gas, water, or all three together, it may be, occupy these numerous little spaces, and thus saturate the rock just as water does a piece of cloth or a sponge when dipped into the same. The larger these pores are, and the greater the volume they occupy in proportion to the volume of the rock mass, the greater will be the contained oil or gas supply, and this proportion in fairly good producing sands, usually varies between one-fifth and one-tenth."[2]

DEFINITION OF ROCK PRESSURE.

When nature generated or deposited the natural gas in the rock reservoir—made up of the microscopic cavities between the sand grains—a fixed amount of gas was placed in a fixed inclosed space. The pressure in the rock—called "rock pressure"—was the result of the pressing into this fixed rock space of a larger volume of gas than the mere free air capacity of this rock reservoir. The degree of compression employed by nature in the formation process deter-

[1] Deviation of Natural Gas from Boyle's Law, by Robert F. Earhart and Samuel S. Wyer. Transactions American Society Mechanical Engineers, vol. 38, p. 285.

[2] I. C. White, West Virginia Geological Survey, vol. 1, p. 155.

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mined the intensity of the resulting pressure in the reservoir; that is, a high degree of compression produced a high rock pressure, and a low degree of compression produced a low rock pressure. Typical rock pressure decline curves are shown in figures 3 and 4.

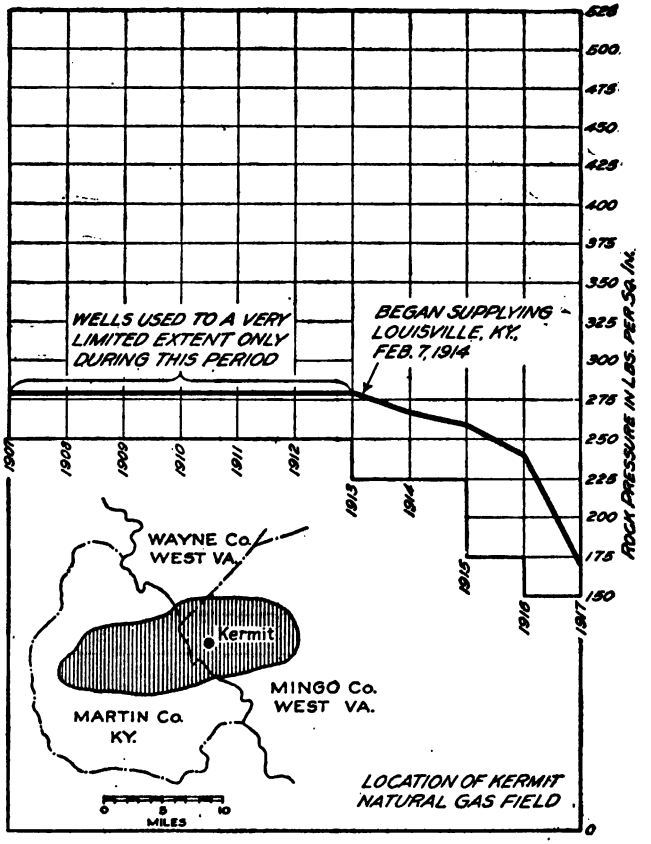

FIG. 3.—DECLINE IN ROCK PRESSURE OF NATURAL GAS WELLS OF THE UNITED FUEL GAS CO. IN KERMIT FIELD IN KENTUCKY AND WEST VIRGINIA.

WHY ROCK PRESSURE AND VOLUME MUST DECLINE.

The rock pressure and volume must decline as gas is removed, because in the removal of the deposit of gas we are confronted with the following:

1.—A fixed volume of the reservoir.

2.—A fixed amount of gas inclosed in this fixed reservoir.

3.—A certain rock pressure resulting from the contraction of the gas volume into the fixed reservoir.

Now, if a part of this fixed volume of gas is removed by tapping the reservoir from the surface of the earth, the remaining gas volume

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expands and keeps the reservoir completely filled, but at a lower pressure. Rock pressure decline is therefore inevitable whenever any gas is removed.

REGENERATION.

Food and trees can be grown. Water supplies are constantly replenished by nature, but there is no regeneration in natural gas; and

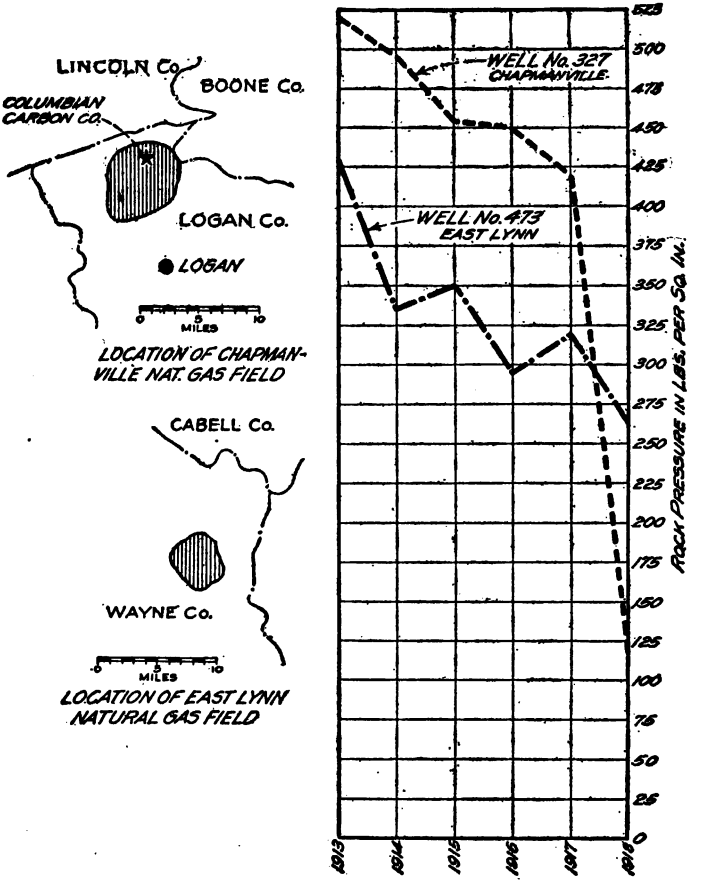

FIG. 4.—DECLINE IN ROCK PRESSURE OF NATURAL GAS WELLS OF THE UNITED FUEL GAS CO. IN EAST LYNN AND CHAPMANVILLE FIELDS, W. VA.

when the gas is once used it is gone forever. While no one knows exactly how the natural gas is formed, yet enough facts are known about it to indicate that nature's process was a very slow one. It has taken millions of years to make the present concentrated supplies, and even though gas should now be formed in some parts of the earth's crust, the rate of formation will be so slow as to make such new gas pools of no interest or economic value for centuries, if ever.

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STORAGE OF NATURAL GAS.

Storage facilities for natural gas are not commercially feasible in the field nor at the delivering end of the transmission line, except the very limited use of existing gas holders in distributing plants. The large variation in service demands must therefore be met by the wells and reserve acreage. That is, the entire field operations must be subordinated to the peculiar service demands made on the natural gas company. An interesting contrast with these stringent operating conditions is the large storage equipment in acres of tank farms that may be used to equalize the load in the oil industry.

LIMITS OF GEOLOGY.

While earth structure is the essential element in the accumulation of large quantities of natural gas or oil, geological science is a directional indicator and hazard reducer only, and not a guarantor of commercial results.

Geology answers that by careful attention to her precepts, much of the waste that characterized the first three decades of the search for petroleum can be avoided, but that it is beyond her powers to foretell absolutely as to whether any particular boring will yield either oil or gas in commercial quantity. The careful geologist can eliminate many of the factors of uncertainty, and thus limit the search to regions having a peculiar geological structure where experience has shown that the occurrence of oil and gas is most probable, but further than this geology can not go, and no skillful geologist has ever claimed otherwise.[1]

LIMITS OF UNDERGROUND RESERVOIRS.

There is absolutely nothing fixed from the surface, and while surface conditions may be indicative, the question of underground location can be established by the drill alone. Even the presence of gas sand is not necessarily an indication of the presence of gas, as many dry holes show the full sand formation, without any gas in the sand. The dry holes shown in the map of the Triple State Field on plate 7 indicate a typical field situation, emphasizing the inability to determine underground limits except by drilling a hole.

OPEN OR NATURAL FLOW.

The courts have used the term "natural flow" synonomously for the engineering term "open flow," both, however, meaning exactly the same thing.

The term "natural flow" necessarily means the entire volume of gas that will issue from the mouth of a gas well when retarded only by the atmospheric pressure. (Appellate Court of Indiana, 66 N. E., p. 782. Richmond Natural Gas Co. *versus* Enterprise Natural Gas Co.)

[1] I. C. White, West Virginia Geological Survey, vol. 1, p. 158.

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The marked difference between the open flow of a gas well and the actual flow that may be obtained under routine operating conditions is emphasized in the next section.

MISLEADING WELL CAPACITY.

The natural gas well capacities that are given to the public are always the open flow capacity; that is, the capacity of the well in 24 hours when discharging freely into the atmosphere with no back pressure at all. This is misleading, and comes far from representing the true service capacity or true gas delivery capacity under routine operating conditions, of any gas well, because:

1. The first open flow measurements, which are usually the ones advertised in the newspapers, are nearly always made by the drillers, who do not have the facilities or skill to make an accurate test, and the errors are invariably on the side of a capacity larger than the actual facts. The volume is determined immediately after the well comes in, and is therefore larger than it would be several days afterward, on account of the fact that the well has not been drawn upon.

2. In routine operations of natural gas wells it is not possible to keep a well in service 24 hours, day in and day out. For various operating reasons, such as repairs, salt-water troubles, etc., it is necessary to rest wells at intervals. For this reason, the actual operating period of a well will be, on an average, very much less than 24 hours a day.

3. It is not feasible to maintain atmospheric pressure conditions in the pipes into which the wells discharge, but, on the contrary, the pressures are very much higher than atmospheric pressure. For this reason, the wells must discharge against considerable back pressure, thus retarding the amount of gas that will go out.

4. Based on actual operating tests, it has been determined that 25 per cent of the open flow capacity is about all that can be delivered from the average natural gas well. It must also be borne in mind that the open flow capacity will constantly decrease, with the removal of gas from the well.

5. As the rock pressure declines it will be necessary to install compressing stations in order to transmit the gas into and through the main transmission line.

6. After the compression station has been installed, the further inevitable decline in rock pressure will lower the capacity of such station, as shown on page 29.

MIGRATORY AND FUGITIVE NATURE OF NATURAL GAS.

Natural gas has no fixed position under any particular portion of the earth's surface. On account of its inherent tendency to expand it has the power, as it were, of self transmission and is capable of flow-

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ing from place to place in the underground reservoir, or of being drawn off by wells penetrating the natural reservoir at any point. Therefore, when one owner of the surface overlying the common reservoir exercises his right to remove natural gas, the supply in the reservoir will be decreased and the amount available to other owners of the surface in contiguous territory must inevitably diminish.

EXTENT OF NATURAL GAS UNDERGROUND DRAINAGE.

Gas is the most uncertain, fluctuating, volatile, and fugitive of all mining properties. It lies far below the surface, beyond the control of human will and beyond the reach of any legal process. On account of the characteristics just mentioned it is impossible to know at what distances drainage takes place. This depends on the unknown character of the sand and whether a well 500 feet or 1,000 feet distant would drain natural gas from an adjacent tract is largely a matter of conjecture and surmise.[1]

QUALITY AND QUANTITY OF NATURAL GAS FIXED BY NATURE.

The quantity is always uncertain and the quality may vary through a small range for the different fields. However, it is not commercially feasible to attempt to correct variation in quality by any artificial means and furnish a gas that is uniform, as may be done in an artificial gas plant, for the simple reason that the cost of doing this would be much more than the additional worth of the service under such conditions.

SCARCITY OF NATURAL GAS.

Natural gas is an exhaustible resource that when once used is gone forever. Every time a natural gas company sells 1,000 cubic feet of gas it is selling a part of its property. Furthermore, the number of natural gas consumers is increasing faster than the number of producing wells, thus placing an additional burden on each well, and the wells that are being drilled at the present time have a lower average capacity than wells that were drilled several years ago, in this way making less gas available.

The decline in average acres land held per natural gas well and average delivering capacity per natural gas well for the entire State of West Virginia is shown on page 22.

The decline in number of acres for a natural gas well of the United States Steel Corporation, operating under the name of the Carnegie Natural Gas Co., in West Virginia, is shown on page 23.

The decline in number of acres natural gas land for each well of the United Fuel Gas Co. is shown on page 24.

[1] Paraphrased from Huggins *versus* Daley, 99 F. R., p. 606, and Hall *versus* South Penn Oil Co., 71 W. Va., p. 82.

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For another operating company representing nearly 40 per cent of the State's production we have the following:

1. Number of acres natural gas land owned to a domestic consumer decreased from 3 acres in 1910 to 2 acres in 1917.

2. The average open flow capacity of new wells drilled declined from 1,200 M [1] in 1913 to 700 M in 1917.

3. The average annual production to a well declined from 3,600 M in 1910 to 2,200 M in 1917.

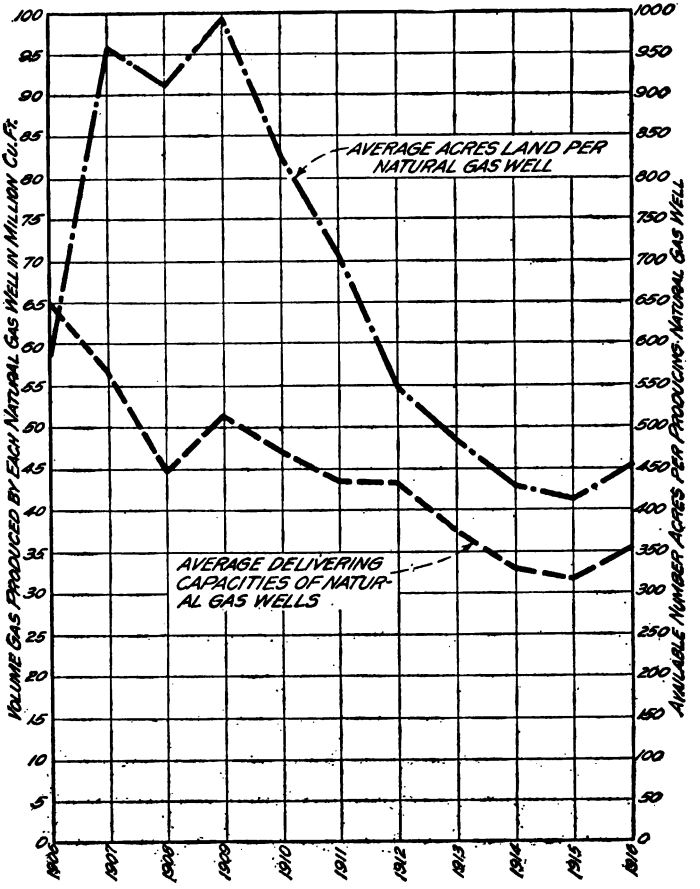

FIG. 5.—DECLINE IN WEST VIRGINIA NATURAL GAS RESOURCES, BASED ON DATA COMPILED BY THE UNITED STATES GEOLOGICAL SURVEY.

4. The number of domestic consumers that could be served by each producing well declined from 250 in 1910 to 170 in 1917.

5. Simultaneously with the above decline, the average annual gas service demands to the domestic consumer increased from 110 M

[1] The letter "M" represents "1,000 cubic feet," the unit of gas measurement.

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cubic feet each year in 1910 to 153 M cubic feet each year in 1917. The demands for West Virginia natural gas are emphasized elsewhere.

NATURAL GAS SERVICE IS BASED ON A NONCREATABLE AND NONREGENERATIVE MINERAL.

The natural gas business is unique in that it is the only public utility service that does not, and in fact can not, create the basis feature of the service that it renders to the public. Manufactured

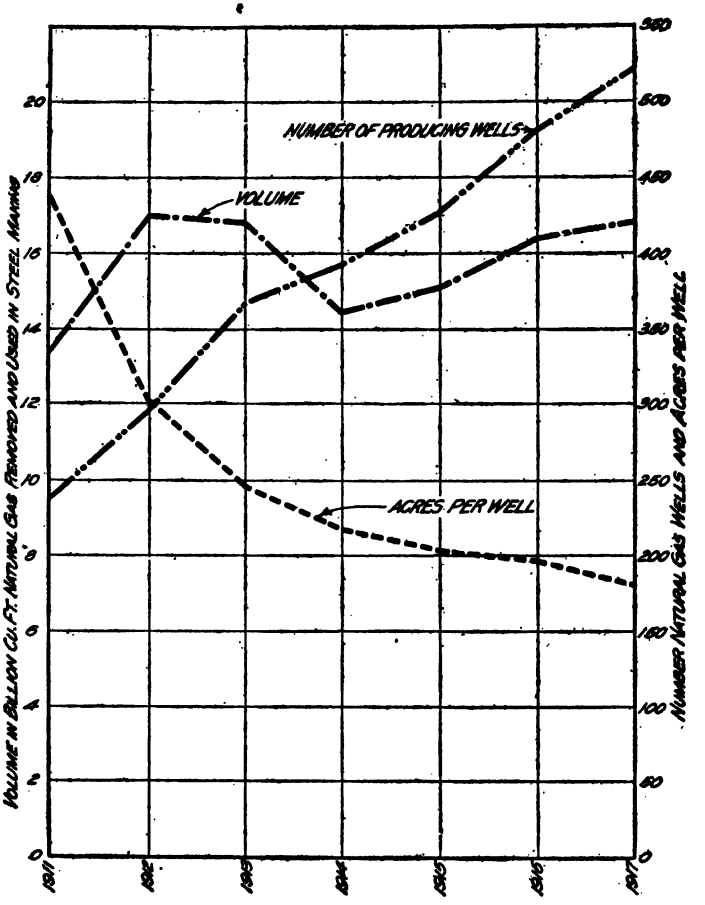

FIG. 6.—USE OF WEST VIRGINIA NATURAL GAS FOR STEEL MAKING, BY UNITED STATES STEEL CORPORATION.

gas companies merely produce their gas from the raw fuel that they can buy in the open market; transportation agencies, like railroads or street railways, can easily create the motive source of their service; water utilities have their water supply constantly replenished by nature; intelligence transmission utilities, like the telephone and telegraph, can easily create the primary source of their service. However, the natural gas industry is alone in depending entirely on

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the caprice of nature for first the finding, and secondly the continuity of the supply of its primary source of public utility service.

NATURAL GAS SERVICE AND OIL BUSINESS DISTINGUISHED.

Gas can not be gathered, stored, or transported in the same manner as oil. If found in sufficient quantity, it is turned from the well into the line and the pressure at the mouth of the well is the motive power by which it is driven through the line to the consumer miles away. If the pressure at a given well is much below that in the line with which it is connected, the gas from that

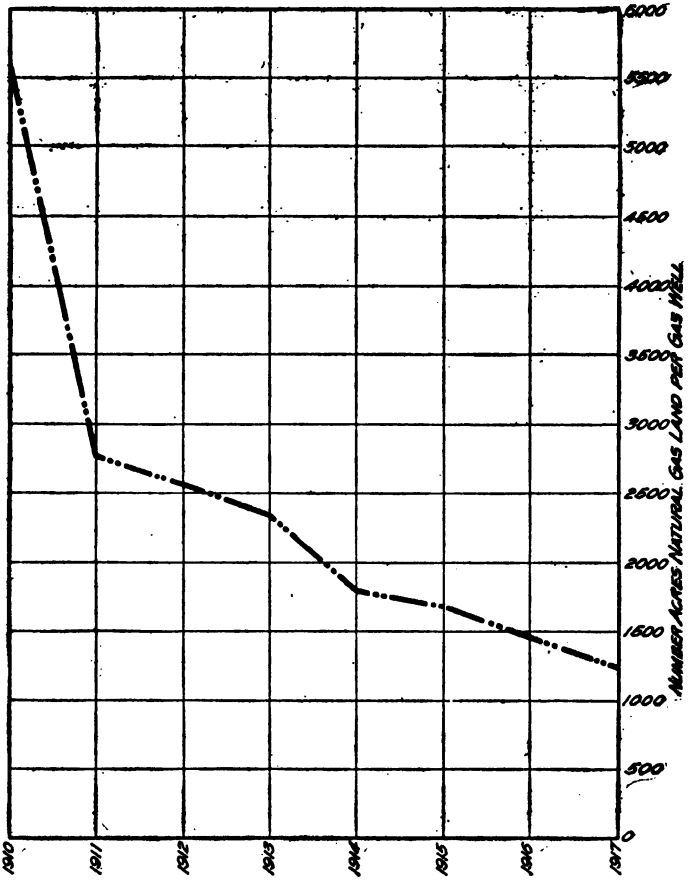

FIG. 7.—DECLINE IN NUMBER ACRES AVAILABLE NATURAL GAS LAND RESERVED FOR EACH NATURAL GAS WELL OF THE UNITED FUEL GAS CO.

well can not enter the line, but will be driven back by the superior force it encounters at the point of connection. For this reason, a well, producing gas in sufficient quantity to be profitably utilized, if there was a market for it near at hand, may be entirely valueless if its product must find a market at a distance too great to justify its transportation by a line of its own. In an oil district each well, no matter how large or how small its product may be, is separately operated, and a well may be profitably operated so long as its yield

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pays more than the cost of producing the oil. In a gas district this is impracticable. The product of many wells is gathered into one line, so long as the pressure is sufficient. When the pressure in any one falls below the standard necessary for purposes of transportation, that well must be turned off. Its product can not be transported separately,[1] and unless it can be used near by, it is valueless. (Pennsylvania Supreme Court: McKnight *versus* Manufacturers Natural Gas Co., 146 Pa. St., p. 185.)

DRYING NATURAL GAS.

Natural gas as defined on page 10 is made up of a mechanical mixture of condensible vapors and permanent gases; the condensible

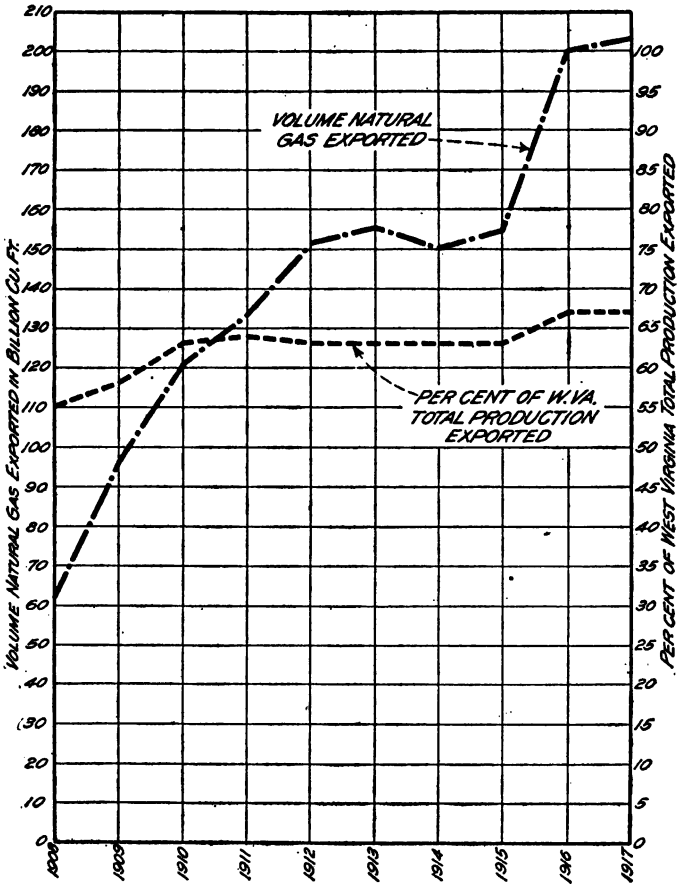

FIG. 8.—NATURAL GAS EXPORTED FROM WEST VIRGINIA.

constituents consist of gasoline vapor and water vapor. In the transmission of the gas, due to changing temperature and pressure

[1] Gas compressors can, of course, be installed so as to increase the pressure of the gas to permit its delivery into a line. The operating cost of this, however, may be much more than the market value of the gas. This, of course, is a very pointed illustration of the fundamental fact that in order to make gas conservation possible it must be made worth saving.

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conditions, part of these vapors are condensed and then precipitated in the form of a liquid, and will give trouble in choking up the line, and the water may freeze, closing the line entirely.

The gasoline will soften and decompose the rubbers in the couplers. This is due to the solvent action of the gasoline on the rubber, and the immediate effect will be to cause the joints to leak, thereby greatly increasing the leakage loss.

The general tendency of natural gas is to become wetter as the well becomes older, and, therefore, natural gas from a new well that may be so dry as not to yield any gasoline at all, may yield gasoline in commercial quantities after the well has been in use for several years. The removal of the gasoline and water vapor carried by natural gas is desirable from the consumers' viewpoint for the following reasons:

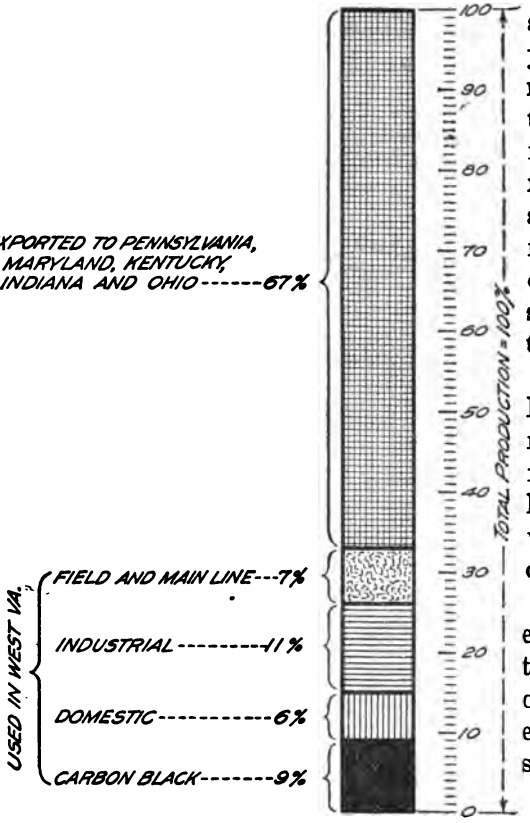

FIG. 9.—USES OF WEST VIRGINIA NATURAL GAS IN 1917.

1. Heating value is little disturbed, the removal of the gasoline from dry natural gas lowering the heating value only about 2 per cent.

2. Gasoline vapor exists in such a form that practically none of it ever can be delivered to the ultimate consumer.

3. The condensed gasoline vapors will injure the rubber in the couplers and in this way increase the leakage of the transmission line.

4. The condensed water vapor will freeze, causing interruption of service, or disturbed and fluctuating pressure conditions.

5. The removal of water and gasoline by blowing the drips results in a large waste of natural gas.

6. The drying of the gas tends to stabilize the gas service by decreasing line troubles.

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Similar conclusions have been presented by the United States Geological Survey, on pages 645 and 646, in Natural Gas Statistics for 1916, and in Bulletin No. 120, page 11, of the United States Bureau of Mines.

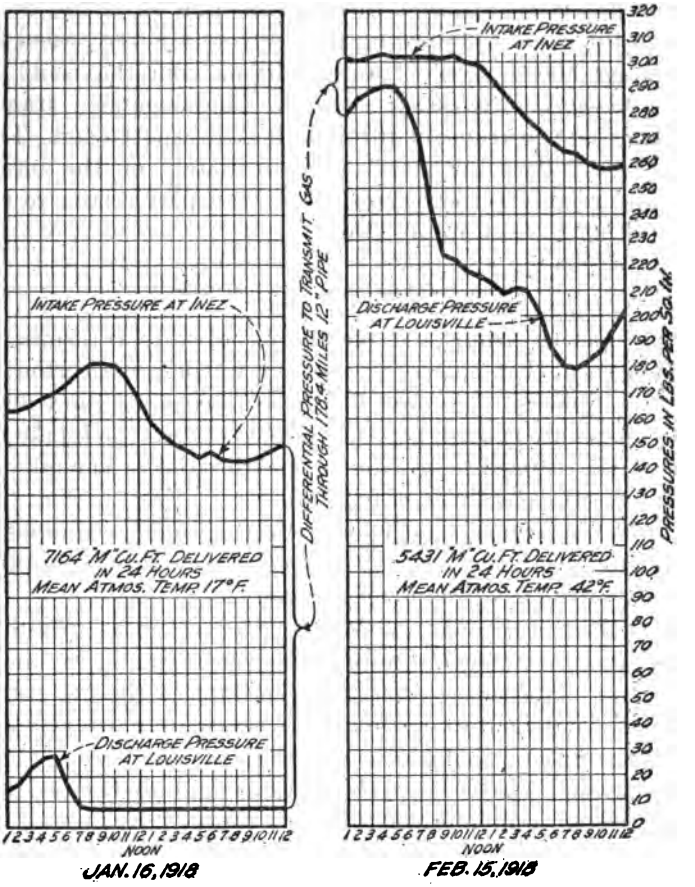
INTAKE PRESSURE AT INEZ
DISCHARGE PRESSURE AT LOUISVILLE
DIFFERENTIAL PRESSURE TO TRANSMIT GAS THROUGH 172.4 MILES 12" PIPE
7164 M CU. FT. DELIVERED IN 24 HOURS MEAN ATMOS. TEMP. 17°F.
5431 M CU. FT. DELIVERED IN 24 HOURS MEAN ATMOS. TEMP. 42°F.
PRESSURES IN LBS. PER SQ. IN.
NOON
JAN. 16, 1918
FEB. 15, 1918

FIG. 10.—TYPICAL NATURAL GAS TRANSMISSION LINE PRESSURE CONDITIONS.

PRINCIPLES OF NATURAL GAS TRANSMISSION.

TRANSMISSION IS MORE THAN MERE TRANSPORTATION.

Continuity of service from the gas sand—usually one-half mile or more below the earth's surface—through the gas main as a continuous conduit connecting the gas sand and the consumer's fixtures, many miles away, is a cardinal feature of the delivery of natural gas. The general custom of the natural gas business has been to refer to the taking of natural gas from the gas sand to the consumer as transportation. However, the word transmission more correctly expresses the actual operation.

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Transmission from the roots, *trans*=across, and *mitto*=to send, emphasizes the fundamental ideas of "to send through" and "to send" and where interstate lines are involved, to "send across" such lines. The fundamental idea "to send" is especially relevant, because the gas is always sent through the line by virtue of its own expansive force, as explained on page 101, and never pulled through by anything ahead, while transportation from the roots, *trans*= across, and *porto*=to carry, suggests fundamentally transference only. That is, you transmit through, but transport over. Transmit, for "to send," fixes the attention immediately on the intervening agency and relates to the service, while transport relates to the commodity, although both imply delivery.

WHY NATURAL GAS IS COMPRESSED.

Natural gas is compressed merely to expedite transmission—for the same reason that makes it necessary to compress cotton, hay, or straw, for shipment. The first feature is to contract the volume, and secondly, to secure enough pressure range between the intake and discharge of the transmission line to secure a large enough pressure drop to force the gas through the line.

The broad public interest in an effective and continuous service and a future generation's equity in a conserved future supply makes it the duty of the gas-producing company:

1. To conserve the supply of gas in every way possible. By conservation is meant not merely saving, but using in the most effective manner. This means that it is the duty of the gas company—when it can be done without financial loss—to remove every foot of gas from the ground that can be obtained.

2. Every appliance known to the art ought to be used to bring about the most economical mining of the gas, and most effective method of transmission and distribution. A normal characteristic of every gas field is that its rock pressure declines each year as the gas is removed from the ground, as shown in graphical form in figures 3 and 4. This means that as the fields grow older it is necessary for the gas company to increase the rapidly declining pressure by mechanical means.

HOW NATURAL GAS IS COMPRESSED.

This is accomplished by a compressor which is merely a mechanical device to squeeze the gas together into a small volume, thereby increasing its pressure. The specific effect of gas compression is evident from the following: If we take 1,000 cubic feet of gas at 4 ounces gage pressure and increase the gage pressure to 300 pounds, the volume will be contracted to 46 cubic feet.

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STATUS OF GAS COMPRESSOR ART.

The art of natural gas compression is now over 29 years old and has grown at practically the same rate as the increase in domestic natural gas consumers. There are now over 220 natural gas compressor stations in North America, aggregating approximately 350,000 horse power of compressor capacity and compressing about 90 per cent of all the natural gas used. The age and magnitude of the art make it evident that the use of gas compressors is a recognized integral part and universal custom of the natural gas business.

"GAS COMPRESSING" AND "GAS PUMPING."

These terms, unfortunately, are almost universally used synonymously to describe the contraction of volume of gas by compressing it with a machine known as a gas compressor.

Much misunderstanding has arisen because the term pumping station has come into general use in speaking of gas compressor stations. This is wrong, for the reason that the term pumping signifies the action of lifting alone, or lifting combined with force. In the case of natural gas transmission the work is one of pure compression, since the gas is delivered to the gas compressors under an initial pressure considerably higher than the atmospheric pressure, on account of the natural rock pressure forcing the gas out from the wells into and through the intake lines to the compressors.

ROCK PRESSURE DECLINE LOWERS COMPRESSOR CAPACITY.

As the rock pressures of the gas wells decline, the pressures that have been maintained on the intake side of the gas compressors are also lowered. This has the immediate effect of lowering the capacity of the compressing station.

The output of a typical compressor operating against a discharge pressure of 300 pounds gage is as follows, for the respective intake pressures:

Intake pressure above atmosphere.	Capacity in million cubic feet free gas each 24 hours, based on 14.4 pounds atmospheric pressure.
150 pounds	30
100 pounds	20
75 pounds	15
50 pounds	10
30 pounds	6
20 pounds	4

SIZE AND COST OF LINES NECESSARY WITHOUT COMPRESSORS.

From an engineering viewpoint it would be possible to take the gas to market without compressors, by simply building a great number of large size lines. However, the number and cost of lines neces-

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sary to do this would be so great as to make the plan prohibitive from a financial viewpoint. That is, the gas compression method is the economical way of handling the problem. The natural gas compressor performs a similar function to the step-up transformer for an electrical transmission line.

NO HEAT LOSS IN NATURAL GAS COMPRESSION.

Contrary to a widespread popular opinion, the compression of natural gas does not decrease its heating value. While a certain amount of gas is used to drive the compressors, this does not in any way affect the heating value of the gas passing through the compressors. On account of the mechanical work performed on the gas as it flows through the compressors the gas becomes quite warm, and to protect the rubbers in the main lines, is cooled just beyond the compressor discharge before it goes into the main line transmission system. This, however, pertains merely to the temperature of the gas itself, and in no way affects its heating value.

NOT FEASIBLE TO MAKE NATURAL GAS MAIN LINES COMMON CARRIERS.

The natural gas main lines form the connecting link between the mining operations in the natural gas field and the public utility service in the city distributing plants. A number of attempts have been made by large consumers, owning natural gas in the field, to have the main transmission lines made common carriers so that they could be compelled to haul the large consumer's gas to market. The converting of main lines into common carriers is not only not feasible from an operating viewpoint, but the idea could be based only on distinctly local and selfish interests, and would ignore entirely the domestic consumers' interest. That is, this plan would greatly injure service to the over 2,000,000 domestic natural gas consumers in the United States, because it is not generally appreciated that:

1. There is a clear distinction between the duties of a common carrier or railroad, and the duties of a public utility.

(*a*) The terms "railroad," "common carrier," and "public utility" are frequently confused. A railroad is a common carrier that undertakes for hire to transport persons or goods, or both, from place to place, for all persons indifferently. The fundamental duty of a railroad or common carrier being indifference as to who shall be served, and an equal readiness to serve all who apply in the order of their application. On the other hand a property becomes a public utility only when dedicated to a public use.

(*b*) Even though legislative enactments would be passed declaring natural gas lines public transportation agencies—that is, common carriers—they could not be enforced because such legislation would be in direct conflict with well-known economic and engineering

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facts. The entire natural gas transportation problem is controlled by economic and engineering laws. These laws can neither be abrogated nor altered by company policy, contractual relations, public opinion, legislative enactment, or judicial decree. They are entirely independent of human opinion, and as certain in their operations as the law of gravitation. Therefore, no mere statement of any governing body can make a public transportation agency of a natural gas line.

(*c*) The fundamental requirement of a common carrier agency like a railroad is nondiscrimination, and this can in no way be applied to the duties of a natural gas company. A natural gas company operating a natural gas transmission line and supplying domestic consumers, from the very nature of things, gives its own consumers preference on account of public policy and the contractual relations existing between such consumers and the gas company.

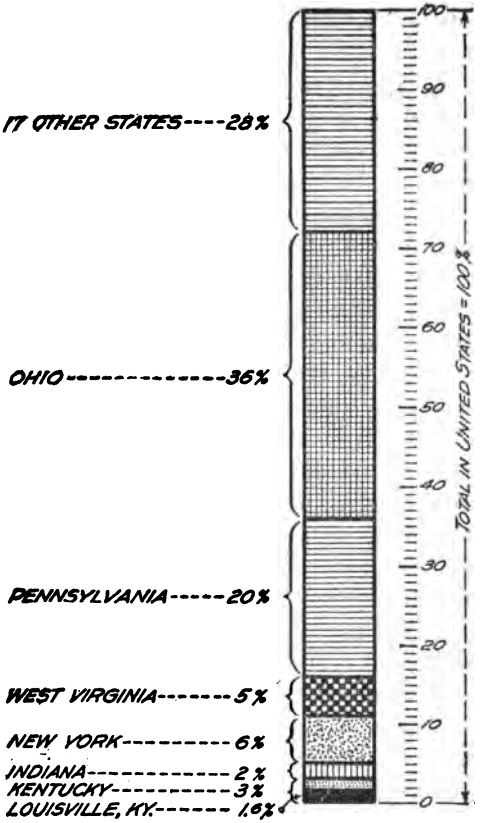

FIG. 11.—GEOGRAPHICAL DISTRIBUTION OF DOMESTIC NATURAL GAS CONSUMERS BY STATES.

2. The consumers' interests and rights extend clear back to and depend on the gas wells and reserve acreage the producing company maintains to insure an adequate present and continuous future service. Common carrier obligations for the transmission line would:

(*a*) Tend to soon exhaust the available supply and leave the householders with large investments of appliances and pipes which will be useless, owing to the permanent failure of gas.

(*b*) So disorganize the existing business as to make it impossible to render satisfactory continuous service to either domestic or industrial consumers. This would be true regardless of what might be charged.

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(*c*) Make the consumers—especially the domestic—subordinate to occasional producers; that is, to men who have no intention of following the business of hunting for gas for future service, but would be interested only in finding a good market, at the expense of others, for such gas as might be found as a result of an occasional accidental venture.

(*d*) In all cases, where tried, impair and usually destroy the cooking, heating, and lighting service of the domestic consumer.

(*e*) Greatly increase the amount of gas used for manufacturing purposes, thus hastening the day when natural gas will be merely the memory of a wasted and unappreciated resource.

3. The attempt to convert natural gas transmission lines into mere common carrier transportation agencies, like railroads, presents many features that are impossible and none that are feasible or expedient, because:

(*a*) Natural gas companies in general are not chartered to act, and do not offer to act merely as transportation agencies.

(*b*) Natural gas service to the public is so unlike the service rendered the public by railroads that no comparison can be made between them.

(*c*) The distinction between handling a commodity and rendering a service is an important one, as explained on page 34.

(*d*) Even though natural gas is a mineral it requires constant attention from the time it is reduced to possession at the well, and embodies an unbroken chain of service features until it is burned at the consumer's fixtures. A railroad may operate its line in many small units, rendering service to many different localities and to many different people with unrelated, isolated service units.

(*e*) Natural gas service must be instantaneous. There can be no delays in rendering service, as is possible (and universally practiced) in transportation agencies such as railroads and traction lines. For instance, a railroad can very easily start service one hour late in case of congested traffic, but a natural gas service that delivers gas for cooking breakfast one hour after the consumer needed it would not only be valueless to the consumer, but would not be tolerated in any community. This instantaneous feature differentiates natural gas service from all transportation agencies.

(*f*) The gas is never at rest, but is a constantly seething, moving mass between the gas in the field and the consumers' fixtures in the cities. The gas travels at enormous velocities in the mains at a speed many times exceeding that of the fastest trains.

(*g*) The gas can go in only one direction.

(*h*) Storage facilities are not feasible for the gas either in the field or in transit.

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(*i*) The gas pressures must be varied to suit the operating conditions of the line; that is, at the intake of the line the pressure must be large and at the discharge end of the line the pressure must be relatively low as shown on page 27.

(*j*) There is no delivery until the gas has not only passed through the consumer's meter, but is burned at the consumer's fixtures.

(*k*) In considering the gas that goes through the line there can be no "identity of property," no "segregation of ownership," and no "original package containers," but all of the gas obtained from various sources passes through the line thoroughly intermixed with absolutely no possibility for identification.

(*l*) The capacity of the transmission lines is rigidly fixed and will not stand any overload. This has a marked effect in taking care of peak loads, in contradistinction to railroads, which may run extra trains to carry extra traffic.

(*m*) A natural gas line can handle only one commodity, whereas railroads can handle every known commodity.

(*n*) Railroads have vehicles of transportation. Natural gas lines have none. The pipe line is merely a continuous conduit between the field and the consumer's fixtures.

(*o*) A natural gas line can not have extensive interconnecting service with other lines, whereas every railroad can handle commodities from every other railroad.

(*p*) The transmission of natural gas is naturally centralized relatively near the fields of production, the deliveries being made near the fields, and not throughout the whole United States, as are commodities handled by railroads.

(*q*) The domestic gas consumers will not contract for, or agree to use, a fixed amount of gas each day, but take gas as they need it, in all cases insisting and requiring that the service be made and maintained continuous.

(*r*) The company can not create the commodity upon which it is performing its service as is possible with manufactured gas, electricity, or any of the transportation agencies; neither is there the constant replacement by nature of the commodity it is serving, as is the case in waterworks plants.

(*s*) The system must be operated as one unit, without regard to state lines.

4. Gas companies discharging their legal duty to their domestic consumers can not depend upon the initiative of the occasional producer for a supply of gas, but must depend upon their own initiative in order to maintain proper field operating conditions and an adequate reserve acreage for future development to insure a good serv-

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ice to their patrons. In West Virginia the total production is delivered as follows:

	Per cent
Utilities	8
Small producers, with no public utility duties	1
Carbon black manufacturers	
	10

Experience has many times shown that satisfactory continuous service to the consumer can be rendered only when the production, transmission, and distributing features are properly coordinated. To subordinate the transmission side of the business to either the producer's or the larger industrial consumer's interest is indefensible.

NATURAL GAS DISTRIBUTION.

NATURAL GAS IS A SERVICE, NOT A COMMODITY.

The furnishing of a service, rather than the delivering of a commodity or product, is the dominating feature of the natural gas business. To consider the gas merely as a commodity is fundamentally wrong. When a natural gas utility prospects for, finds, and reduces the fugitive, wandering and uncontrolled natural gas to possession, and then converts this crude natural gas—made up of a mechanical mixture of permanent gases and condensible vapors—into a controlled and usable service delivered to the consumer's fixtures, usually many miles from the gas field, the service features pertaining to the method and manner of delivery, and standing ready to serve are of much more importance than the product or commodity.

The difference between rendering a service and marketing a commodity is an important one. The commodity may be manufactured at a uniform rate of production and then placed in storage until it can be sold to advantage, while a service must be used at the moment it is offered or it will become forever useless. The load factor data on page 35 emphasized, first, the erratic nature of natural gas loads and, secondly, the potential opportunities for rendering service that can never be used.

WHY GAS CONSUMERS USE MORE NATURAL GAS THAN MANUFACTURED GAS.

The average consumption in M cubic feet of natural gas for all the domestic natural gas consumers in the United States is 100 M cubic feet by each domestic consumer annually. The consumption data for Charleston, Huntington, and Louisville, Kentucky, is shown in graphical form on pages 35 and 36.

The average of 682 manufactured gas companies, as reported in Brown's Gas Directory, was 22 M cubic feet of manufactured gas to each domestic consumer a year. The actual average annual con-

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sumption of manufactured gas at Louisville, Kentucky, prior to the introduction of natural gas was 24 M cubic feet.

The reasons for this large increase in domestic natural gas consumption are as follows:

1. Natural gas prices have been so low as not to make the gas worth saving.

2. The efficiencies of most natural gas using appliances are generally less than for manufactured gas using appliances. See page 40.

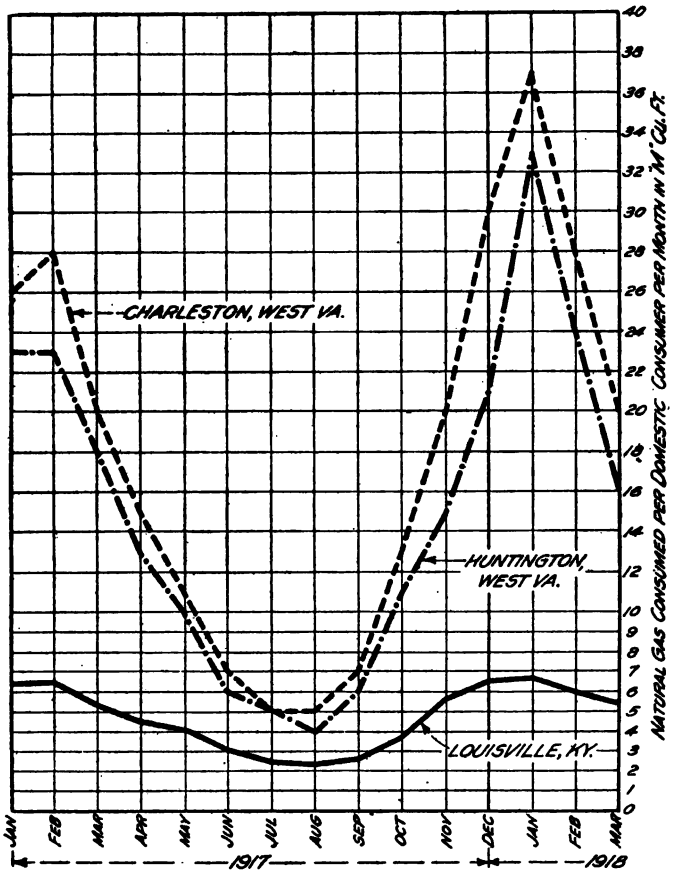

FIG. 12.—MONTHLY AVERAGE NATURAL GAS CONSUMPTION PER DOMESTIC CONSUMER.

3. Manufactured gas is used primarily for cooking, hot water heating, and lighting only. The largest part of the natural gas business results from its extensive use for house-heating services, where the volume required is very much greater.

PEAK LOAD SERVICE.

Abnormal peaks of very short duration are characteristic of all natural gas loads for domestic consumers. This necessitates a large

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property value for equipment that is actually used only a very short period out of each year. Every natural gas company must have considerable equipment that will be used not over four hours daily during say 30 of the coldest days of a year of normal temperature. The smallness of this is evident from the following:

Total number hours in the year_____ 24 × 365 = 8,760 = 100 per cent.
Hours peak load equipment is actually used _____ 4 × 30 = 120 = 1.4 per cent.

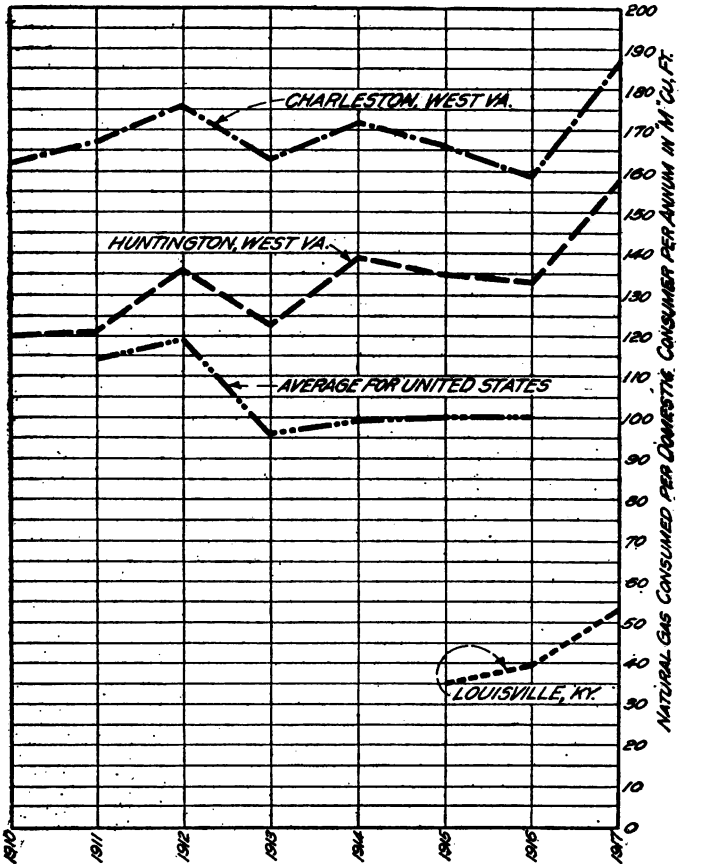

FIG. 13.—ANNUAL AVERAGE NATURAL GAS CONSUMPTION PER DOMESTIC CONSUMER.

Industrial loads ordinarily are very much more uniform than domestic loads. This is especially true of the carbon black industry in the field, where the load can be made uniform every day of the year. The relationship between maximum, minimum, and average load conditions is shown on page 37.

PEAK LOADS INCREASE COST OF SERVICE.

An increase of volume of business can decrease the cost of production only when the increment of increase is distributed so as to make

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possible the more efficient use of existing equipment. When the increment of increase is concentrated so as to require more equipment, as is the case in all peak loads, the cost of production to the unit of service is increased. Therefore, the cost of peak load natural gas service is greater than the cost of normal service. A rate schedule, to be equitable to all consumers of natural gas, must make the consumers who need and create the peak load service, pay a price that will be commensurate with the extra cost of the service they are receiving.

House heating furnace services not only produce marked peaks each day, but the consumption is limited to relatively a short period out of each year. For this reason house heating furnace service costs more than ordinary gas service. This emphasizes the desirability of the use of auxiliary heating equipment, as outlined on page 38.

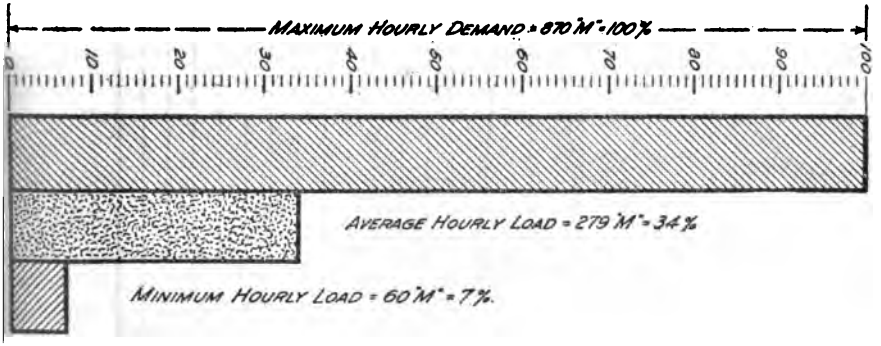

FIG. 14.—RELATION OF MAXIMUM, AVERAGE, AND MINIMUM HOURLY NATURAL GAS LOADS.

BASIC REASONS FOR LARGE SALES OF INDUSTRIAL GAS.

These have been inadequate domestic price and policy of Government in fostering competition in the gas field.

During the domestic off-peak period—usually nine months of the year—about 60 per cent of the equipment of a gas company is not needed for domestic natural gas service. Under competitive conditions in the field the gas can not be conserved for future use, except by unity of action of all producing companies. As the Government has always fostered competition, and therefore waste, the inevitable result has been to stimulate low-priced industrial gas sales, because:

1. The companies needed the revenue to make up the deficit from their too low priced domestic gas service.

2. As no one company could save its gas, except by the prohibitive "unity of action of all producers," each took all the gas it could get, as fast as it could get it out, thereby greatly depleting the supply for future service.

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At the present time of all the gas produced in the United States, practically two-thirds is used in industrial service. The percentage of total State consumption that is used for industrial service, for several States, is shown on page 39.

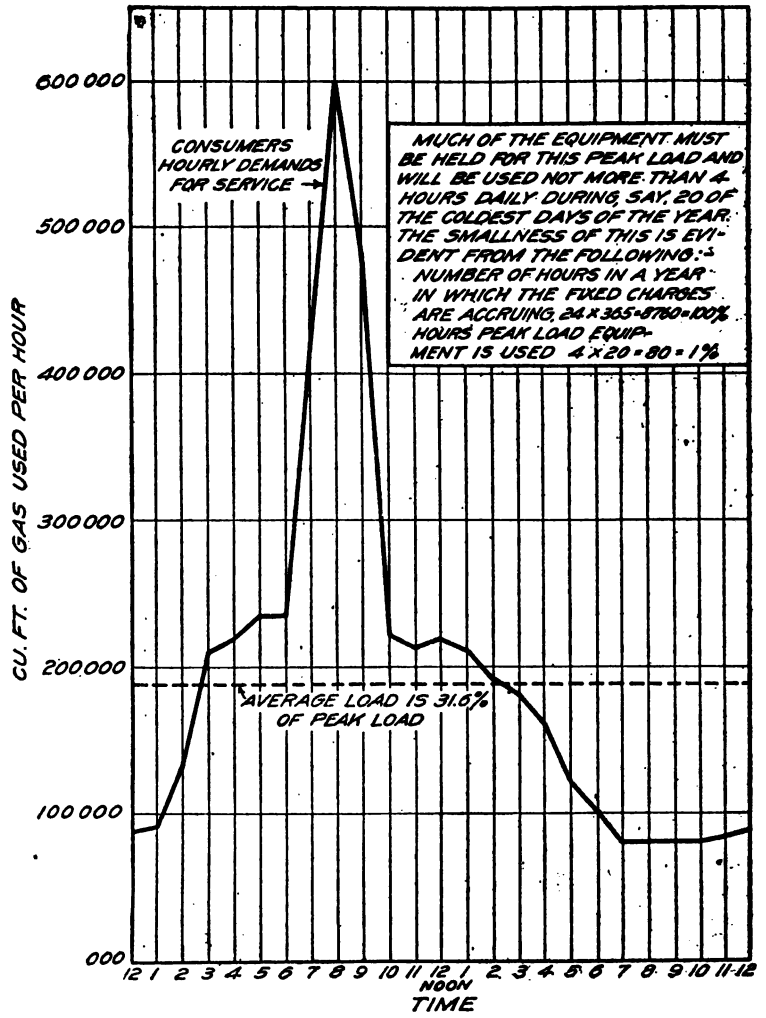
600 000
500 000
400 000
300 000
200 000
100 000
000
CU. FT. OF GAS USED PER HOUR
CONSUMERS HOURLY DEMANDS FOR SERVICE →
MUCH OF THE EQUIPMENT MUST BE HELD FOR THIS PEAK LOAD AND WILL BE USED NOT MORE THAN 4 HOURS DAILY DURING, SAY, 20 OF THE COLDEST DAYS OF THE YEAR. THE SMALLNESS OF THIS IS EVIDENT FROM THE FOLLOWING:- NUMBER OF HOURS IN A YEAR IN WHICH THE FIXED CHARGES ARE ACCRUING, 24 × 365 = 8760 = 100% HOURS PEAK LOAD EQUIPMENT IS USED 4 × 20 = 80 = 1%
AVERAGE LOAD IS 31.6% OF PEAK LOAD
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON
TIME

FIG. 15.—TYPICAL HOURLY NATURAL GAS LOAD IN WINTER.

The pooling operating conditions referred to on pages 62 and 63 would greatly curtail this misuse of gas for industrial purposes.

PEAK LOAD CONDITIONS ANALOGOUS TO STRAP HANGER PROBLEM.

While it would be possible for a street car company to install and operate enough cars during the peak-load period to give everyone

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a seat, yet the cost of so doing would make the general service cost much more than the additional advantages would be worth. Since the demand for seats may be four or five times as great during the rush hours as it is in the middle of the day, the only feasible way to deal with this situation is to admit the necessity of a different standard of service for rush and nonrush periods. Since the fare remains constant, it becomes necessary to provide relatively fewer cars, and therefore fewer available seats, for the rush period than for the nonrush travel.

But for the uniformity of street railway rates, the rush hour passenger might justifiably be charged more than the nonrush passenger. Conversely, it is not unreasonable that he should, paying the same fare, expect to have to put up with a somewhat less comfortable ride at that time. There is certainly little economic ground for an especially reduced fare for this service.[1]

This is precisely the situation with regard to natural gas pressures during the peak load period, with this further feature, that the natural gas peak load periods cover relatively only a few days of the year, as against the everyday situation on street car traffic. As long as natural gas prices for the higher costing peak load service remain the same, the consumer must therefore expect a lower standard of service during that period.

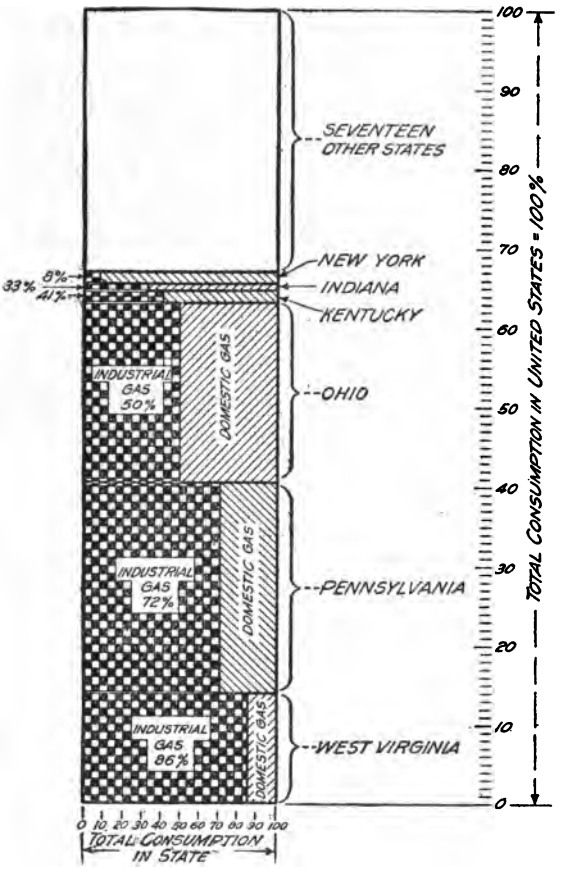

FIG. 16.—RELATION OF INDUSTRIAL AND DOMESTIC NATURAL GAS CONSUMPTION.

[1] Quarterly Journal of Economics, August, 1911, p. 623.

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USE OF AUXILIARY HEATING APPLIANCES.

It is desirable in all cases where possible to have auxiliary heating equipment available for supplementing or entirely replacing for a short period natural gas for house-heating service, during the peak period of the load. Where gas furnaces are used, auxiliary oil burners can be installed in such fire pots, or auxiliary coal furnaces can be installed alongside the gas furnaces, where the coal furnace would discharge its heated air into the gas furnace shell.

FEW IMPROVEMENTS IN ART OF USING NATURAL GAS.

On account of the low prices that have prevailed, gas-appliance manufacturers have not been stimulated to the development of efficient gas-using equipment. There have been few improvements resulting in increased efficiency in the last 15 years. In testing house-heating furnaces it has been found that:

1. The use of natural gas in the fire pot of a coal furnace gives an efficiency of about 25 per cent.

2. The use of natural gas in the ordinary gas furnace gives an efficiency of about 35 per cent.

3. The use of natural gas in a correctly designed and built gas furnace, where the construction conditions permit the fullest utilization of the heat in the gas, gives an efficiency of about 75 per cent.

In tests made by the Bureau of Standards, it was found that the ordinary incandescent mantle lamp where used with natural gas wasted nearly half of the possible heat that could be used if such lamps were designed for as efficient operation on the high heating value natural gas as they give on the low heating value manufactured gas.

In tests made by the department of home economics, Ohio State University, the efficiencies of a natural gas range varied from 37 per cent with 0.2 of an ounce pressure down to 13 per cent at 4-ounce pressure,[1] while with a manufactured gas range, using natural gas, the efficiencies varied from 43 per cent at 0.2 ounce pressure to 23 per cent at one-ounce pressure.

COOKING AND HEATING DISTINGUISHED.

In a heating operation it is merely necessary to secure perfect combustion in the heating device, because in so doing all of the available heat in the gas can be utilized. In cooking it is not only desirable to secure a perfect combustion, but absolutely necessary to direct the heat to a particular place, in a particular manner, and sometimes at a particular time. It is for this reason that gas-cooking operations are

[1] Ohio State University Bulletin, vol. 22, No. 28, May, 1918: Effect of Gas Pressure on Natural Gas Cooking Operations in the Home.

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more susceptible to changed pressure conditions than heating operations.

It may not be amiss to emphasize that the time element in many cooking operations is of much more importance than intensity.

WHAT IS USABLE NATURAL GAS PRESSURE.

The pressures carried by most natural gas companies have been too high for efficient service. This has had the further undesirable feature of teaching the consumer to believe that he was not receiving service unless the gas could be heard hissing through the orifice in the gas mixer. It has been demonstrated that [1]—

1. Satisfactory cooking operations in frying potatoes, boiling potatoes, frying beefsteak, and pan-broiling beefsteak can be carried on with 0.2 ounce natural gas pressure. This merely requires that the short flame and cooking vessel be brought together. The changes in vessel position necessary to permit satisfactory operation at pressures as low as 0.2 ounce are easy to make, require no special changes in existing stoves, and consist merely, with drilled burners, in placing three nails in three of the drilled holes, and, with slotted burners, of placing three small pieces of tin in three of the slots, in order to support the cooking vessel at the proper distance from the burner, and close enough so that the short flame can do effective work.

2. Better results are obtained with pressures in the neighborhood of 2 ounces than at 4 ounces.

3. Less gas is used at pressures in the neighborhood of 2 ounces than at 4 or 5 ounces.

4. Manufactured gas range gives better results than natural gas range because the former is designed for low pressures.

5. There is very little difference in the time required to carry on cooking operations with pressures of from 1 to 5 ounces.

Therefore, if the consumer will use proper appliances, satisfactory cooking operations can be carried on with pressures as low as 0.2 ounce and the gas passing through the meter will perform a usable service.

With heating appliances, if the mixer is properly adjusted the combustion at low pressures can be made substantially as thorough as at high pressures, and the consumer can have the benefit of all the heat generated by the burning gas, although if the pressure is low he will invariably not have nearly as much as he would like to have or as he needs. However, all of the gas measured by the meter and burned in the heating appliance is used for a useful service, so far as it goes, although under extreme low pressure conditions there is not enough to give all consumers all they want.

[1] Ohio State University Bulletin, vol. 22, No. 28, May, 1918: Effect of Gas Pressure on Natural Gas Cooking Operations in the Home.

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ACCURACY OF METER REGISTRATION AT LOW AND VARIOUS GAS PRESSURES.

The popular belief is that meters run faster when the pressure is low than when the pressure is high. This is contrary to the facts. Variation in pressure makes no appreciable difference in the registration of the meter, the meter merely registering, within a reasonable limit of tolerance, the amount of gas that passes, and this is neither increased nor decreased by changes in pressure.[1]

EFFECT OF GAS PRESSURE ON GAS LEAKAGE.

A summary of gas leakage laws is given on page 58. From these it will be seen that the leakage at 4-ounce pressure is twice as great as at 1-ounce. For this reason the leakage in the city distributing plant and on the consumer's premises, which is paid for by the consumer because the gas must pass through the consumer's meter in order to leak away on his premises, will be substantially less if the distributing plant and consumer's fixtures are adjusted for low pressures rather than high pressures.

GAS METER FACTS.

The following features regarding gas meters should be borne in mind:

1. Gas meters have no power within themselves to register. The only way they can be made to register is by the passage of gas through the meter. The gas company has absolutely nothing to do with the operation, nor can it in any way control the registration of the meter. However, many times gas meters register when gas is not being used, due to leakage in house fixtures.

2. The gas consumption will not be increased by the use of a large meter.

3. The gas consumption will not be decreased by the use of a small meter. In fact, if the meter is too small the gas service will be unsatisfactory.

4. Gas bills are not made out regardless of gas consumption. While it is possible for the meter reader to make an error for one month, this will be automatically rectified in the reading of the following month.

5. High gas pressure does not increase or decrease the rate of registration of meter.

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[1] The same conclusion was reached in: Engineering Bulletin No. 2 of the University of Kansas, on Natural Gas: Its Properties, Its Domestic Use, and Its Measurement by Meters, under date of July 1, 1912. Paper on Value of Gas Delivered at Varying Pressures, by Charles V. Critchfield, of the Ohio Public Utilities Commission, read at the Pittsburgh meeting of the Natural Gas Association of America, May, 1918. Ohio State University Bulletin, vol. 22, No. 28, May, 1918: Effect of Gas Pressure on Natural Gas Cooking Operations in the Home.

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6. Low gas pressure does not increase or decrease the rate of registration of the gas meter.

7. It is impossible for a gas meter to register twice. When the gas has passed through the meter it can not pass through the second time.

8. Meters do not always register fast. There are just as many times when they register slow, and this is to the detriment of the gas company.

DISTINCTION BETWEEN LUXURY AND NECESSITY IN NATURAL GAS SERVICE.

To the average family for cooking, hot water boiler heating, lighting, and incidental house heating service, natural gas is a necessity, but when used in larger quantities or for house-heating furnace work it becomes a luxury. Furthermore, the peak load characteristics of house heating furnace service make this service cost more to the natural gas company. An equitable schedule of rates ought, therefore, to provide for a fixed net price per thousand cubic feet for a large enough monthly consumption to permit of the cooking, hot water boiler heating, lighting, and incidental house heating service necessary in the average family. If this fixed consumption is exceeded, then the price of a thousand cubic feet for such excess consumption ought to be increased so as to make the consumer pay for the higher priced service he is receiving.

It is a trite observation that the luxuries of one day tend to become the necessities of the next. Most complaints for inadequate service during the few peak load hours, usually less than 1 per cent of the total 8,760 hours in the year,[1] are based on the fallacy that a service that is purely a privilege has become a prerogative; that is, natural gas consumers as compared with other fuel users who have to use solid fuel or manufactured gas are a privileged class enjoying a luxury that is seldom appreciated until it becomes difficult to obtain, and on account of the limitations fixed by nature they do not possess and can not ask any inalienable rights of service, under conditions that are physically impossible to meet.

CONSUMER IS RESPONSIBLE FOR ECONOMIC USE OF GAS.

The consumer's use of gas has an important bearing on the efficiency of results that may be obtained, as discussed on page 40. Few people appreciate that even in an ordinary frying operation effective results can not be obtained unless the vessel position is close enough to the flame so that the tip of the flame can deliver the heat generated in an effective manner. Even with high pressure and long flames, if a strong draft should deflect the flame the cooking service will be unsatisfactory.

[1] Few people appreciate that even if the service averages below normal 5 hours a day for 17 days, the total period of normal service is still more than 99 per cent.

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When mantle burners are opened so as to admit more gas than is necessary, the familiar "hissing" or blowing sound is produced. This has, first, a tendency to break the mantle and chimney; second, waste the gas; and, third, lowers the candlepower of the lamp. The majority of natural gas consumers do not appreciate that gas burners need care and attention and that periodic cleaning is absolutely essential if satisfactory results are to be obtained.

The data given on page 40 show the marked differences in results that may be obtained in using natural gas in the fire pot of an ordinary coal furnace, as against a specially built natural gas furnace.

BAROMETRIC CHANGES MAKE MORE DIFFERENCE ON TOTAL PRESSURE THAN GAGE PRESSURE VARIATION.

On account of the changing atmospheric conditions, the barometric pressure varies from day to day and from hour to hour on the same day. Thus, the atmospheric pressure at Louisville, Ky., on January 21, 1918, was 30.47, and on January 11 was 29.19 inches, this difference of 1.28 inches of mercury being the equivalent of 0.627 pound to the square inch, or 10 ounces to the square inch, or considerably more than the entire range of variation in gage pressure.

ATMOSPHERIC TEMPERATURE CHANGES HEATING VALUE OF GAS MORE THAN CHANGES IN GAGE PRESSURE.

The variation in mean monthly temperature of natural gas at Louisville, Ky., is shown on page 45.

The variation in temperature of natural gas in the underground mains makes more difference in the heating value than the variation in gage pressure. The maximum fluctuation in temperature produces a difference in heating value of about 5 per cent, while the maximum fluctuation in pressure produces a difference in heating value of less than 4 per cent. Furthermore, these variations work in opposite directions; that is, in winter time when the pressure is low, therefore tending to decrease the heating value, the temperature is low, tending to increase the heating value. This increase due to low temperature will always be more than the decrease due to low pressure.

EFFECT OF PRESSURE OR TEMPERATURE CHANGES ON HEATING VALUE OF GAS.

These will produce changes in volume, but will neither destroy nor create any heat units, and hence will neither increase nor decrease the total number of heat units contained in the gas. However, the volumetric changes will always alter the distribution of the total number of heat units, as follows:

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Gage pressure above atmosphere.	Relative British thermal unit.	Relative per cent.	Gage pressure above atmosphere.	Relative British thermal unit.	Relative per cent.
Ounces.			*Ounces.*		
8	1,034	103.4	3	1,013	101.3
7	1,030	103	2	1,009	100.9
6	1,026	102.6	1	1,005	100.5
5	1,022	102.2	0	1,000	100
4	1,017	101.7			

Gas temperature.	Relative British thermal unit.	Relative per cent.	Gas temperature.	Relative British thermal unit.	Relative per cent.
° *F.*					
70	960	96	50	1,000	100
65	970	97	45	1,010	101
60	980	98	40	1,020	102
55	990	99	35	1,030	103

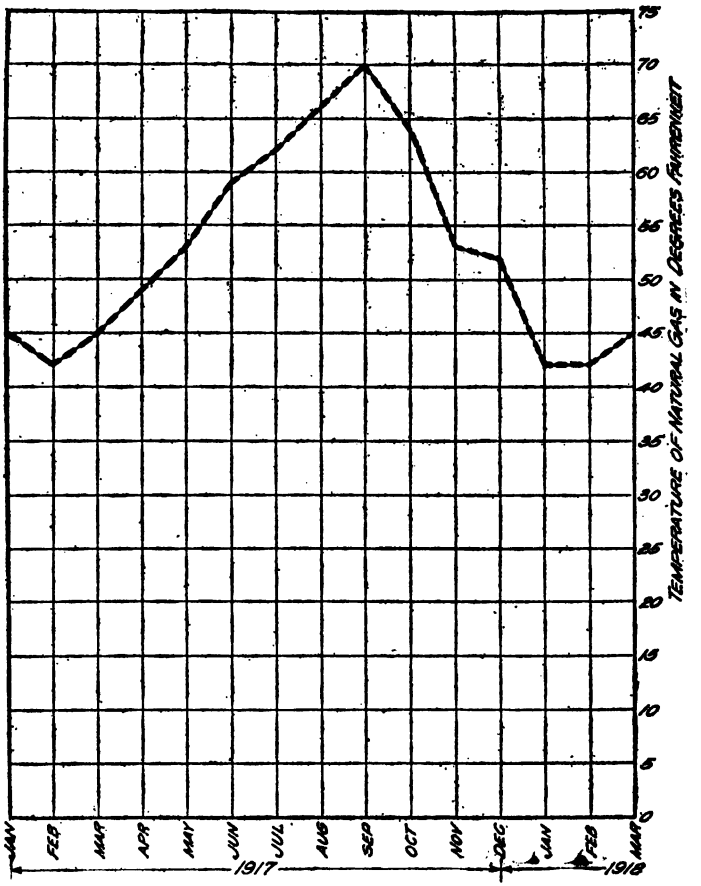

FIG. 17.—MEAN MONTHLY TEMPERATURES OF NATURAL GAS IN GAS MAINS.

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COMBUSTION OF NATURAL GAS.

The combustible constituents of natural gas are made up of combinations of the elements carbon and hydrogen. When natural gas is burned so as to secure perfect combustion, only carbon dioxide and water vapor are formed. That is, the carbon of the gas unites with the oxygen of the air forming carbon dioxide, and the hydrogen of the gas unites with the oxygen of the air forming water vapor. The water vapor, of course, will condense when cooled. This water vapor does not come from the gas, but is created and formed by the chemical action of the hydrogen in the gas and the oxygen in the air.

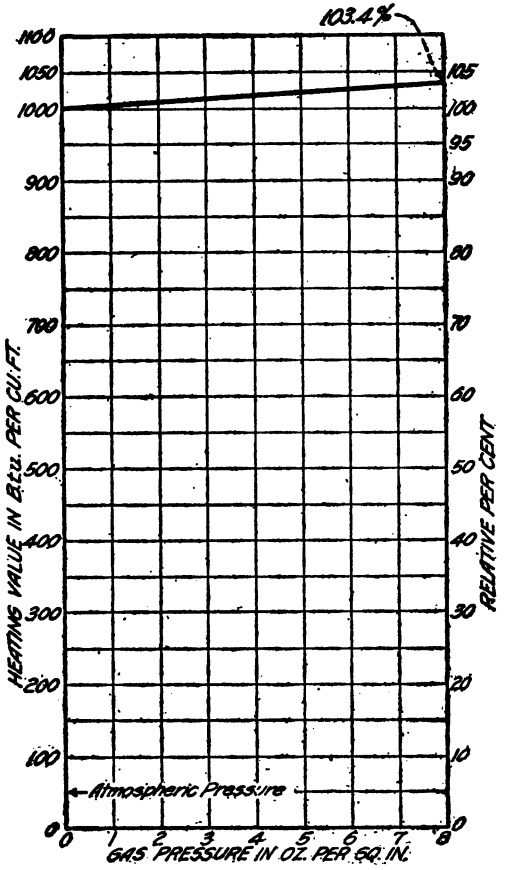

FIG. 18.—CURVE SHOWING EFFECT OF GAS PRESSURE ON GAS VOLUME AND GAS HEATING VALUE.

Each cubic foot of natural gas burned requires approximately 9½ cubic feet of air, forming 10½ cubic feet of combustion products, which are made up of 2 cubic feet of steam, 1 cubic foot of carbon dioxide, and 7½ cubic feet of nitrogen, all thoroughly diffused through each other.

The combustion of 1,000 cubic feet of natural gas will form 2,000 cubic feet of water vapor or steam, and this when condensed will make approximately 10½ gallons of water. This is not peculiar to natural gas, but is true of all gases containing hydrocarbon compounds. One thousand cubic feet of manufactured gas will form about one-half the water vapor produced by the combustion of 1,000 cubic feet of natural gas. It is this water vapor that causes the bakers and broilers of stoves to rust, and where gas is used in open fires without flues, or for lighting, makes the walls and windows sweat and glued furniture open up.

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If the combustion is not perfect, then carbon monoxide, which is a deadly poison, may be formed. The toxic action of this is so marked that one-tenth of 1 per cent is enough to produce fatal results. This is especially likely to be formed when a flame is suddenly impinged on a cold surface, as, for instance, the first few seconds' operation of an instantaneous hot water heater.

EFFECT OF ATMOSPHERIC TEMPERATURE ON DEMANDS FOR GAS.

The temperature of the atmosphere has a direct bearing on the demands for natural gas for heating service. However, the quantity of cooking, incidental hot water heating, and lighting is independent of the temperature of the atmosphere and would be practically constant for the year. The humidity of the atmosphere, direction and velocity of wind, and hours of sunshine, also affect gas consumption, as far as heating service is concerned. In general a high wind causes more of an increase than merely a low temperature. The mean monthly temperature curve plotted upside down will always show a close relationship between volume of gas used and temperature of atmosphere.

DAILY DEMANDS FOR GAS HEATING SERVICE.

The daily gas heating consumption to each degree of temperature below 70° F., at Louisville, Ky., from mean temperatures ranging from 2° on February 2 to 58° on January 29, is shown below.

It will be noted that the heating service for each degree is larger at the warmer temperatures. This is because the general tendency is to keep most houses at a higher temperature than necessary, and for this reason on account of the cheapness of the gas, and the general absence of thermostat control devices, the gas is not used as efficiently.

Daily gas heating consumption for each degree of temperature below 70° F.

Date.	Mean temperature of atmosphere, degrees F.	Difference between mean temperature and 70°, 70–A.	M cubic feet natural gas a day.			
			Delivered to Louisville.	Service independent of atmospheric temperature.	Heating service.	Heating service per degree below 70° F. (E÷B).
	(A)	(B)	(C)	(D)	(E)	(F)
1917.						
Feb. 2	2	68	13,209	4,500	8,709	128
Jan. 14	10	60	12,193	4,500	7,693	128
Jan. 11	20	50	11,370	4,500	6,870	137
Jan. 26	30	40	10,869	4,500	6,369	159
Jan. 6	39	31	9,142	4,500	4,642	149
Jan. 3	48	22	7,852	4,500	3,352	152
Jan. 29	58	12	6,830	4,500	2,330	194
Average						150

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MONTHLY DEMANDS FOR GAS HEATING SERVICE.

When the atmospheric temperature drops below 70° F. demands for heating service are created which are practically proportional to the number of degrees that the atmospheric temperature is below 70. The variation in monthly demands for each degree of atmospheric temperature below 70° F. is shown in the following table.

The data in column D is the estimated gas consumption for cooking, incidental hot water heating, and lighting, which is entirely independent of the atmospheric temperature, and the estimated figure is taken approximately as the total amounts delivered during the months of June, July, August, and September, when there are practically no demands for heating service.

The average of the demands for heating service at Louisville, Ky., for each degree below 70° F., for the months of January, March, April, May, October, and November, 1917, and March 1918, when enough gas was available to meet the demands, was 5,500,000 cubic feet for each month for each degree below 70° F.

Monthly gas heating consumption for each degree below 70° F.

Date.	Mean monthly temperature of atmosphere, in degrees F. (A)	Difference between mean temperature and 70° F., 70-A. (B)	Million cubic feet natural gas a month. Delivered to Louisville. (C)	Service independent of atmospheric temperature. (D)	Heating service (C-D). (E)	Demands for heating service per degree below 70° F. (E÷B). (F)
1917.						
January	36	34	302	140	162	4.8
February	32	38	260	140	120	3.2[1]
March	46	24	260	140	120	5
April	55	15	232	140	92	6.1
May	60	10	204	140	64	6.4
June	72		140			
July	76		131			
August	76		134			
September	69		149			
October	51	19	243	140	103	5
November	45	25	270	140	130	6.2
December	26	44	269	140	129	2.9[1]
1918.						
January	20	50	263	140	123	2.4[1]
February	38	32	223	140	83	2.5[1]
March	51	19	232	140	92	4.9
Average of normal months.						5.5

[1] Not enough gas available to meet demands.

WHY STANDARDS FOR NATURAL GAS SERVICE MUST BE LOWER THAN FOR MANUFACTURED GAS.

The operating conditions in a natural gas plant are so different from those prevailing in a manufactured gas plant that the standards of service that would reasonably be applicable to the latter would not be feasible or expedient with natural gas, because:

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1. The volume of natural gas business for each domestic consumer is generally about five times as large as for manufactured gas.

2. The peak load difficulties in a natural gas load are much more troublesome than in manufactured gas, due primarily to the heating load, which fluctuates with the atmospheric temperature.

3. The service standards can not be limited to merely the distributing plant limits, but would be closely related to the main pipe lines, back into the field to the compressing stations, and general field operating conditions.

4. The natural gas company can not create the basic feature of the service it is selling to the public, but must depend entirely on the caprice of nature for this.

5. Every foot of gas sold represents in effect the sale of a part of the company's property.

6. Since there is no regeneration, the supply can be kept continuous only by constant and persistent hunting for new supplies.

7. Although the distributing end is a public utility service, the field or producing end is a mining proposition, and the continuous connection of the two by the transmission line has the immediate effect of also connecting the mining hazards to the distributing end of the business.

8. The migratory tendencies and fugitive nature of natural gas under the ground make its reduction to possession much more difficult than for solid minerals.

9. In general, the prices for natural gas service have not been adequate, and have not been made on the basis of rendering as uniform a condition of service, especially with regard to pressure, as can be maintained in a manufactured gas plant.

10. Both the quality and quantity are entirely controlled by nature.

DISCOUNT FOR LOWER PRESSURES STIMULATES WASTE.

A penalty clause providing for a discount when pressures less than 4 ounces are maintained has been suggested as a means of guaranteeing good service. However, instead of guaranteeing service it stimulates waste for the reasons given on page 54. The penalty clause is inequitable and fails to recognize the well known operating characteristics of the mining, transmission, and distribution of natural gas, which, therefore, differentiate this from every other type of public utility service, more particularly by:

1. Failure to recognize that the heating value of the gas does not decrease proportionally with the decrease in gage pressure.

2. Failure to recognize that neither the efficiency nor the efficacy of gas decreases proportionally with the decrease in gage pressure.

3. Failure to recognize that higher efficiencies may be obtained at pressures below 4 ounces than at 4 ounces and above.

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4. By ignoring rate of flow or volume of gas to be delivered and the close relationship that exists between volumetric demands and the constantly changing and uncertain and unpredeterminable atmospheric temperature changes.

5. General conservation methods in the field have not been followed in the past; gas has been produced, transmitted, and distributed in a most wasteful manner, which has, therefore, very greatly depleted available supplies, highly desirable for peak-load service.

6. The uncertain, migratory, and fugitive nature of the gas in the underground reservoirs, where it is entirely beyond the control of the human will, legal process, or contractual relationship, and yet where its expansive properties under the ground must be taken as the initial step for the delivering of service to consumers 200 miles away, obviously makes it evident that considerable leeway must be allowed in service standards.

EXTENSION OF SERVICE.

In considering the question of the desirability of making new extensions after a natural gas supply has become depleted, so as to make satisfactory service for all impossible, two distinct viewpoints have been developed, namely:

The Indiana Supreme Court in 1901 held that:

> A natural gas company * * * can not refuse to permit connections with its mains by unsupplied citizens because the gas pressure has fallen so low that existing customers can not be adequately supplied, and that the court should compel the company to permit participation in the supply of gas furnished by it, although it can not furnish enough to satisfy the needs of its existing customers. (State of Indiana ex. rel. Wood *versus* Consumers Gas Trust Co., 55 Lawyers Reports, 245.)

The New York Public Service Commission, second district, in 1915, held that:

> Consideration must be given to a safe and adequate service on the part of the company, within its means and facilities, and if service of this character is being given to a comparatively few customers in a certain locality, with the eliminated amount of gas available for such purpose, it is manifestly the duty of this commission to permit the continuance of such service rather than order the company to turn its gas into a larger field where a safe and adequate service could not be given. (New York Public Service Commission, second district, North Tonawanda case No. 4478, Feb. 25, 1915.)

The Indiana viewpoint is merely a blind following of obsolete precedent. Furthermore, it is based on the erroneous theory that it is a matter of no consequence whether adequate service can be given to any customers, so long as all of the customers stand on an exact equality, and fails to recognize that there is a clear distinction between equity and equality, and that the two are not synonymous.

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The New York viewpoint is in accordance with the spirit and letter of up-to-date public utility regulation and recognizes the inherent characteristics and natural limitations of the natural gas industry, and that usable service to a limited number is better than poor or no service to a large number. This New York viewpoint is the just and equitable one to apply to all new service extension problems, as well as to the inevitable problem that will arise in the near future, of limiting or discontinuing the service entirely in certain localities, because the available supply as furnished by nature will not permit the continuance of a usable service to all.

WASTE AND CONSERVATION OF NATURAL GAS.

DEFINITION OF CONSERVATION.[1]

True conservation is not hoarding, but the wise use of natural resources, and it implies not merely the preserving in unimpaired efficiency, but also a wise and equitable exhaustion with a maximum efficiency and a minimum waste. The heart of the natural gas conservation problem is the conflict between the present and the future. The individual land owner is interested primarily only in immediate present personal returns. That is, he is thoughtless and indifferent with respect to the future. The public—at least the 2,000,000 domestic natural gas consumers and the 10,000,000 people dependent on natural gas for their cooking, heating, and lighting purposes—are interested in conserving the supply and bringing about a slow, wise, and economical exhaustion, so as to insure continuity of service for the future.

Conservation, therefore, demands intensive rather than extensive use, takes cognizance of equitable distribution, aims to bring about social justice, and means the greatest good to the greatest number—and that for the longest time.

EXTENT OF WASTE.

Most of the supply and service problems of to-day are the inevitable result of waste in producing and handling natural gas. The annual reports of the conservation committee of the Natural Gas Association of America are stinging indictments of a criminal system, fostered by both the gas companies and the public, that has resulted in wasting more gas than has ever been utilized. The following expert opinions further reflect this appalling situation:

> The history of the natural gas industry of the United States is an appalling record of incredible waste, but it must be told, in order to explain the need for the remedies proposed.[2]

[1] Phraseology suggested by Prof. C. R. Van Hise's The Conservation of Natural Resources in the United States, and Prof. Richard T. Ely's Conservation and Economic Theory. Trans. Amer. Inst. Min. Eng., vol. 54, p. 458.

[2] Technical Paper 38, United States Bureau of Mines, Waste in the Production and Utilization of Natural Gas and Means for their prevention.

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In my own State of West Virginia only eight years ago not less than 500,000,000 cubic feet of this precious gas was daily escaping into the air from two counties alone, practically all of which was easily preventable by a moderate expenditure for additional casing.[1]

Of all the pieces of extravagance of which the American people have been guilty, perhaps their reckless and wasteful use of natural gas is the most striking—not the most important—but the most striking. This product, severely limited in quantity, which can last only a few years at most, has been handled by us as if it were illimitable.[2]

In reference to natural gas, the great and pressing necessity is to stop its appalling waste by enacting and enforcing proper legislation. This ideal fuel should be used with the severest economy in order to prolong its life, which will be brief at best.[3]

Had the pioneer far-reaching waste eliminating recommendations of Dr. Edward Orton, State geologist of Ohio, and Dr. I. C. White, State geologist of West Virginia, been heeded, most of the acute natural gas service problems of to-day would not exist.

SPECIFIC FORMS OF WASTE.

The various forms of waste may be grouped under drilling, well operation, transmission, and utilization operations.

DRILLING WASTES.

1. *Not closing wells promptly.*—Much gas is wasted on account of delay in closing wells, caused primarily by poor judgment and failure to supply material promptly. In many cases the rock pressure over quite a district has been materially lowered by the delay in closing promptly a single large well in that section.

2. *Improper casing.*—There is much underground waste by improper casing methods which allow gas or water to migrate from their original strata into other strata. This is an especially important feature in the West Virginia fields, where in many instances several gas-bearing formations are superimposed with intervening barren formations.

3. *Waste of gas to air.*—As a result of improper casing methods gas frequently works up around the packer or into the casing above the packer and is wasted in the air.

4. *Gas waste in well-drilling boilers.*—Most gas burning appliances used in well-drilling boilers are crude and inefficient, and the gas is handled as if it had practically no value and were of little use to other people.

5. *Waste of gas in torches.*—A large number of open flame (flambeaux) torches are still in use. Not only is this an inefficient and

[1] I. C. White, State geologist of West Virginia. Address at conference on conservation of natural resources, May 13, 1908.

[2] C. R. Van Hise's The Conservation of Natural Resources in the United States, p. 60.

[3] Idem, 360.

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therefore wasteful method of securing illumination at night but in many instances the torches are not shut off during the day.

6. *Offset wells.*—The drilling of offset wells is not only frequently a waste of capital, resulting from overdrilling, but very frequently results in marked waste of gas. This is discussed in further detail on pages 55–57.

7. *Improper plugging.*—Where a well is abandoned and the casing pulled, if the hole is not properly plugged, it may result in the ruination of other gas bearing formations by the migrating of gas or water from one to the other, or the very great waste of gas leaking into coal veins or coming up and passing out into the air.

WELL OPERATION WASTES.

1. *Wasting gas to get oil.*—Where oil and gas are found in the same field it is quite a general practice for oil operators to blow off the gas, that is, waste it, in order to procure the oil. This is the principal cause of the depletion of many gas fields, and is responsible for a greater volume of gas waste than probably all other causes put together.

In tests on over 1,000 oil wells in West Virginia it was shown that the waste of natural gas of each well was at the rate of 12 M cubic feet a day, or 4,380 M cubic feet of natural gas a well per annum. There are at least 16,000 oil wells in West Virginia, and at this rate the annual waste from this source would be at least 70,000,000 M cubic feet of natural gas, equivalent to about one-third of all the natural gas used for domestic consumption in the United States.

2. *Excessive blowing.*—Where wells are blown into the atmosphere for water freeing purposes the gas must, of course, be wasted. However, in many cases the wells are blown longer than necessary, and in others it would be feasible to install siphons for the removal of the water so as to curtail this form of waste.

3. *Salt water troubles.*—In some instances salt water exists in the gas-bearing formation and in others it works in from other strata, due primarily to improper drilling and casing methods. This results in a large waste of gas when the wells must be watered to free them of the salt formation below in the tubing.

4. *Too rapid lowering of the rock pressure.*—The irregular or too rapid lowering of the rock pressure by exceedingly rapid production will always produce undesirable operating conditions, and must ultimately result in a large waste of the total amount of gas that might have been removed with more rational operating methods.

TRANSMISSION WASTES.

1. *Leakage.*—The structural conditions accounting for much of the leakage along gas lines are discussed in detail on page 58. The

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leakage in the consumer's house piping beyond the meter is very much larger than ordinarily appreciated. In a number of houses where the leakage has been checked it has been found that in their instances the leakage averaged 19 M cubic feet of gas a year for each house.

2. *Measuring devices curtail leakage.*—The leakage problem is very much greater than ordinarily appreciated, due to the fact that in so many instances measuring appliances are not used for measuring the gas either into the line or out of the line. The more extensive use of measuring devices, if properly installed and the results properly interpreted, would reveal an enormous waste in many lines that are now supposed to be tight.

3. *Blowing drips.*—If the gasoline vapors and water vapor are not removed by drying the gas, considerable gas must be wasted where these vapors, after they have been precipitated in liquid form, must be blown out along the transmission system. The installation of gas drying plants will therefore practically eliminate this form of waste in addition to conserving the gasoline.

UTILIZATION WASTES.

1. *Flat rate.*—Much natural gas is still sold at a flat rate of so much per consumer, or so much for each fire or other fixture. This puts a premium on waste and results in the destruction of an enormous amount of gas that might be conserved for more intelligent and appreciated future use.

2. *Cheap gas for manufacturing.*—When natural gas is sold at low prices for industrial use, there is no incentive to use the gas in an efficient manner, and it is therefore quite frequently used without regard to efficiency or conservation. This is probably the largest form of waste in connection with utilization of natural gas.

3. *Free gas.*—In many cases boom towns in the gas fields have held out the inducement of supplying either free gas or the gas has been sold at ridiculously low prices for industries that would locate there. This feature has been especially troublesome in West Virginia and has resulted in depriving many domestic consumers of an adequate supply of the best fuel available for household use.

In an extensive investigation the amount of gas consumed by domestic consumers in West Virginia having free gas service privileges, on account of having gas wells or gas lines on their farms, it was found that the average consumption per free consumer a year was 480 M cubic feet. This is a waste of at least 350 M cubic feet for each free consumer a year. There are at least 4,400 free consumers in West Virginia, and at this rate of waste this item alone amounts to 1,540,000 M cubic feet a year. This is more than half the amount of gas used in Louisville. The following further emphasizes this form of waste:

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Average annual consumption for each free domestic natural gas consumer in West Virginia, 480 M.

Average annual consumption for each domestic natural gas consumer in the United States, 100 M.

Average annual consumption for each domestic consumer at Louisville, 53 M.

4. *Carbon black.*—This is a form of improper use rather than absolute waste. The carbon black industry in West Virginia uses 50 per cent more gas than is furnished to all of the domestic natural gas consumers in that State. The economic reasons accounting for the use of natural gas for carbon black manufacture are discussed in detail on pages 60–62.

5. *Inefficient use.*—In many cases natural gas is used without mixers. The data given on page 40 show the marked difference between the use of natural gas in the fire pot of an ordinary coal furnace and a correctly designed natural gas furnace, and the cooking stove and lighting efficiencies emphasize the need of improvements in gas-using appliances.

6. *Thermostat control.*—Thermostats for controlling house-heating appliances are out of the experimental stage, and the large number in use demonstrates their reliability and usefulness. In addition to ministering to the comfort of the house occupants, they aid very materially in conserving the gas consumption by preventing overheating. Where natural gas is sold at low prices the practice is still all too common of lowering the temperature of an overheated room by opening a window rather than by lowering the gas fire.

7. *Discount for low pressure stimulates waste.*—In a number of instances consideration has been given to a penalty clause providing for a discount when pressures lower than 4 ounces are maintained. This has the immediate practical effect of lowering the price of gas during the peak load period and stimulates waste, for the well-known human nature reason that what is made cheap will not be saved. When the consumer believes that his bills will be lower he will attempt to use more gas than he otherwise would, and in this way the cumulative effect will be to still further lower the standard of service to all, in addition to using the gas in a wasteful manner at a time when every thought should be for conservation of the highest order. Whatever may have been the motive for considering the penalty clause, there can be no doubt but that its effect is abortive.

DEFINITION OF "OFFSET WELL."

After a well has been drilled on one farm, the term "offset well," in a narrow sense, means a well drilled on a contiguous farm, directly opposite from the first well and substantially the same distance across from the farm line.

It is not necessary in all cases that the offset well be either directly opposite to or the same distance from the property line as the

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well that it is to offset. Thus one well may be an offset to two or more contiguous wells. In other cases the shape of the tract will determine the position of the offset well. The primary feature to be borne in mind is that the offset well is drilled for purposes of protection, and that this is more important than hard and fast rules regarding exact location. The adventitious origin, migratory habits, and fugitive tendencies of natural gas, as well as the nature of the sand and the topography of the country, are also factors that must be considered.

DRILLING OFFSET WELLS MAY MAKE EXISTING WELLS COMMERCIALLY WORTHLESS.

In gas territory the lessee may sink many wells and find gas in them all, but he can utilize only such of them as have a volume and pressure sufficient to enable him to transport the gas through his line and deliver it to the purchaser. If no one of them has the requisite pressure, then no one of them can be utilized; the gas must be wasted, the cost of the wells will be lost, and the lessor entitled to no royalty. What is the proper way to operate a gas lease is therefore a question beset with some difficulty. Its settlement requires some general knowledge of the business and some knowledge of the local field. The lessee may have a good well, from which he can utilize the gas with profit. He may put down another on the same farm and thereby so reduce the pressure in the first as wholly to destroy its value, without getting a sufficient pressure at the second to enable him to utilize that. The gas, if coming from one well, would be of great value. Divided in such manner that the whole volume and pressure at each is below the necessary standard, the whole is lost.[1]

WHY OFFSET WELLS ARE FREQUENTLY DRY.

It is a matter of common observation in natural gas mining that offset well locations are frequently dry holes. This is because most natural gas pools are not strictly continuous, but are made up of many small local pools, frequently surrounded in whole or in part by a gas rock of low porosity. For this reason, if a producing well has been drilled into one of these small local gas pools, there is a large chance that the offset well location may go beyond the limits of the pool and therefore be a dry hole.

WHY OFFSET WELLS ARE FREQUENTLY OF LOW CAPACITY.

The fact that offset natural gas wells are frequently of lower capacity than the wells that they offset may be accounted for as follows:

If the offset well is drilled at the extreme edge of a small local pool its capacity would naturally be smaller than the original well drilled more nearly in the center of the pool. Furthermore, when the first well is drilled into the pool the rush of gas from the then high rock

[1] Pennsylvania Supreme Court. McKnight *versus* Manufacturers Natural Gas Co. (146 Pa. St., p. 185).

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pressure has a marked tendency to open up numerous channels of low resistance in the rock formation, so that the gas in the gas sand can get to the well opening with a minimum of friction. The high initial rock pressure aids substantially in first creating such lines of least resistance and then in freeing them of loose particles of sand which are blown out through the well. Even though an offset well is afterwards drilled in the same pool, the initial rock pressure will probably be lower than for the first well, and the lower gas pressure will not be near as likely to produce favorable conditions for flowing to the bottom of the offset well as were produced in the first well.

WHEN IS THE DRILLING OF OFFSET WELLS JUSTIFIABLE?

The crux of the entire "offset well-drilling question" is whether the decision to make the additional investment in drilling offset wells for natural gas, providing the increased annual operating cost for their care and maintenance and cutting down the reserve acreage necessary for future continuity of service, shall be made by the farmer—with no risks involved and no obligation to the public—or the party who must provide the money, assume the financial risk and operating duty to the public. The following correctly expresses the equities of the situation: The development and protection of lines which is implied is such as is usually found in the business of an ordinary prudent man. The operator, who has assumed the obligations, has put his money and labor into the undertaking, and is now called upon to determine whether it will pay to spend some thousands of dollars more in sinking another well to increase the production of the tract, is entitled to follow his own judgment, if that is exercised in good faith, in accordance with the doctrines laid down on page 65.

PUBLIC PAYS FOR WASTEFUL OPERATION.

While the production of natural gas is strictly a mining venture, its distribution to the ultimate consumer is distinctly a public utility service. Even under State regulation of public utilities, any marked increase in the cost of natural gas mining operations will soon be reflected in the price the ultimate consumer must pay for the natural gas service.

The acreage data given in figures 5, 6, and 7 show that not every landowner can have an offset well. The drilling and operation of unnecessary offset wells will represent a large increase in the capital investment and operation cost of natural gas companies. All of such increased burdens represent an unnecessary waste which will ultimately be paid for by the public.

The following analysis gives the reasons for the drilling by one company of 429 wells in West Virginia during 1916, and emphasizes

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the offset well burden, as well as the large number that were drilled on the demands of the lessors.

Reason for drilling:	Number of wells.
To save lease	96
Offset	68
For oil	74
For gas	52
Wildcat	4
Requirements of lease	5
Demand of lessors	130
Total	429

GAS LEAKAGE.

The difficulty in keeping gas joints tight is not ordinarily appreciated and results in an enormous waste from defective joints and minute openings in gas-carrying equipment. The laws controlling gas leakage may be stated as follows:

1. The relative leakage tendencies of any two fluids under the same conditions are practically inversely proportional to the square roots of their respective densities. Natural gas has a density of practically 0.64. With regard to air, the relative leakage of air and natural gas will vary as the square root of 1 and square root of 0.8 or as 1 is to 0.8. That is, the leakage tendency of natural gas will be $1 \div 0.8 = 1.25$ times that of air under similar conditions. Water has a density 819.5 times heavier than that of air; hence leakage tendency of natural gas in comparison to that of water at the same pressure is much greater than that of water. This accounts for the universal difficulty in keeping gas confined without leakage.

2. The quantity of leakage through a given opening will vary directly as the square root of the differential pressure.

3. Amount of leakage is independent of the quantity or velocity of gas passing through the main. In other words, the pressure remaining the same, the leakage will be just as much during the period of low gas consumption as during the period of high gas consumption.

A typical gas main joint coupling, as shown on page 59, has four surfaces adjacent to the rubber and the metal where leakage may be possible. On a 16-inch main each coupler presents about 17 linear feet of such potential leakage surface. The magnitude of this in a large system is evident when we consider that about 270 couplers will be required to the mile, thus making $270 \times 17 = 4{,}590$ feet of possible leakage surface to the mile of a 16-inch gas main.

Welded gas mains are coming into use, but the welded process can not be used except on new work or in such main line installations where the entire line can be shut down and drained of all gas before the welding operation is attempted.

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DEFINITION OF CARBON BLACK.

In the American trade the term "lamp black" is usually understood to be a soot deposited by the smudge process and made from oil, rosin, or some other solid or liquid raw material, whereas "carbon black" is the term applied to a black deposited by actual contact of a flame upon a metallic surface.[1]

WASTE IN CARBON BLACK MANUFACTURE.

Carbon black is now made by the wasteful process of incomplete combustion of natural gas. That is, the gas is simply burned in the open and the flame impinging against a metal plate makes the black deposit known as carbon black. From 1⅛ to 1½ pounds of carbon

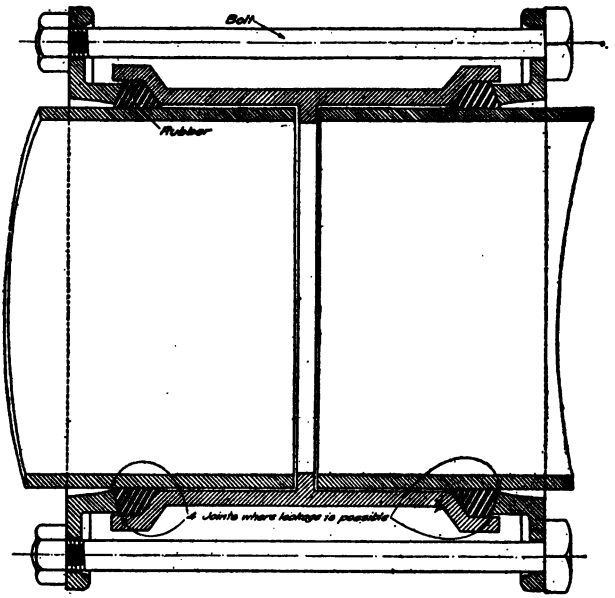

FIG. 19.—LONGITUDINAL SECTION OF GAS PIPE COUPLER SHOWING FOUR POSSIBLE LEAKAGE JOINTS.

black are made to each M cubic feet of gas burned. The only product obtained is the carbon black, and this utilizes only a very small percentage of the total carbon content of the gas.

The total annual quantity of natural gas used for carbon black manufacture is more than 26,000,000 M cubic feet. This wastes about 10 times as much gas as was used in the city of Louisville, or the equivalent of one-eighth of the domestic natural gas consumption in the United States.

Dr. J. B. Garner, of the Mellon Institute of Industrial Research, Pittsburgh, Pa., has demonstrated that with correctly designed appliances the yield of carbon black can be made three times as high

[1] U. S. Geological Survey Statistics. Natural Gas in 1916, p. 662.

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as that usually obtained by the wasteful process of incomplete combustion, and in addition thereto save a usable commercial gas.[1]

WHY CARBON BLACK MANUFACTURE MAY BE MORE ATTRACTIVE THAN PUBLIC UTILITY SERVICE.

1. *No regulation.*—Not carrying with it any public duties, it is not subject to the many phases of public regulation that control the marketing of natural gas as a public utility service.

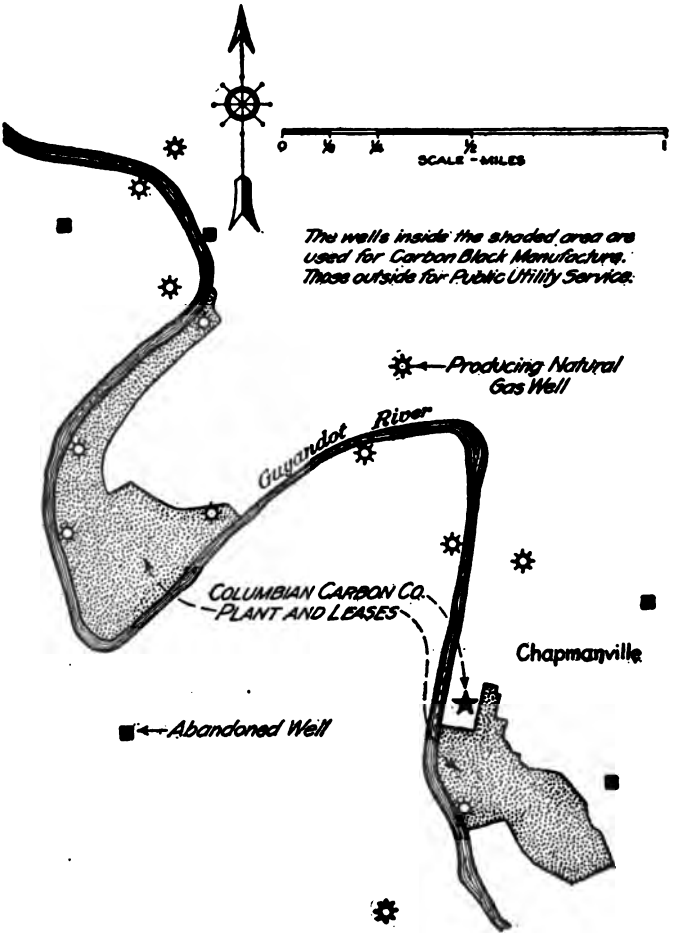
0 ⅛ ¼ ½ 1
SCALE - MILES
The wells inside the shaded area are used for Carbon Black Manufacture. Those outside for Public Utility Service.
Producing Natural Gas Well
Guyandot River
COLUMBIAN CARBON CO. PLANT AND LEASES
Chapmanville
Abandoned Well

FIG. 20.—MAP SHOWING COMPETITION FROM CARBON PLANT AT CHAPMANVILLE, W. VA.

2. *Price.*—This is not controlled by rate fixing bodies, but is limited solely by the ordinary laws of trade, and is, therefore, more attractive from the investor's viewpoint than governmental price fixing.

3. *No transmission lines necessary.*—The plants are located in the fields, as shown in figure 20, close to the leases, and sometimes on

[1] J. B. Garner The Chemical Possibilities of Natural Gas. Paper, Natural Gas Association of America, Pittsburg meeting, May 23, 1918.

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the leases themselves, so that the ordinary gathering lines are the only transmission equipment necessary, and these are so short as to not even require the use of gas compressors. This, of course, makes a marked difference in leakage loss, due to short lines, as well as installation cost.

4. *Uniform load.*—A natural gas plant operating as a public utility, as shown in graphical form on page 37, can use its total equipment only about one-third of the time. That is, it has a load factor of only about 34 per cent. The carbon plant load is uniform every hour in the day and for every day in the year. With the same wells and gathering line equipment it can, therefore, handle approximately three times as much gas as it could if it were selling its gas to the public as a public utility service.

5. The proximity of the carbon plants to the wells, with the resulting short lines, makes it possible to carry lower well pressures than can ordinarily even be reached by contiguous public utility companies having their wells discharge into intake lines to compressor stations. This, in most cases, gives the carbon plant the advantage in pressure over the adjacent competing public utility plant.

6. In a number of instances carbon plants have been located where it would not be feasible, with present prices for natural gas, to lay lines in order to transmit the gas into the public utility transmission systems.

7. The carbon black plants do not carry reserve acreage, as a general rule, and this lowers the capital necessary for the enterprise.

8. The plant hazards are much less than those in a public utility plant.

9. The investment necessary for each 1,000 cubic feet of natural gas handled will be about 10 times larger in a public utility plant than in a carbon black plant, as explained in further detail in the next section.

SMALL CAPITAL IN CARBON BLACK PLANT AS COMPARED TO PUBLIC UTILITY PLANT.

It is not ordinarily appreciated that the investment necessary to render natural gas service is very much greater to each consumer than for any other utility service. That is, the investment to each consumer in natural gas properties, from gas leases to domestic meters, is—

1. Three hundred per cent more than in electric plants, thus requiring $4 investment in natural gas plants to $1 in electric plants for each consumer.

2. One hundred and fifty per cent more than in waterworks plants, thus requiring $2.50 investment in natural gas plants to $1 in waterworks plants for each consumer.

3. One hundred per cent more than all of the Bell Telephone toll lines and Bell exchanges in the United States, thus requiring $2 in-

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vestment in natural gas plants to $1 in telephones for each consumer.

4. Fifty per cent more than in ordinary manufacturing gas plants, thus requiring $1.50 investment in natural gas plants to $1 in manufacturing plants for each consumer.

The investment from reserve acreage to domestic consumer's meters in a natural gas plant rendering public utility service and selling on an average of about 100 M cubic feet of natural gas to each domestic consumer a year will be about $220 to each consumer, or $2.20 for each M cubic feet of gas delivered a year.

The investment in a carbon black plant for each M cubic feet of natural gas that may be used a year, taking into account all of the favorable factors enumerated in the preceding section, will be only about 20 cents for each M cubic feet.

This is an unappreciated factor that must be reckoned with in future natural gas service standards.

COMPETITION ALWAYS ECONOMIC WASTE.

Competition in a gas field always results in a duplication of lines, unnecessary wells, enhanced operating cost, lack of proper coordination, failure to remove all the gas, and shortened life of the field, with the inevitable resulting injury to the domestic consumer.

Under competitive conditions, even where the underground gas reservoir is made up of many local pools, various operators will drill into the same local pool, and thus drain out the gas from under each other's leaseholds.[1]

EASE IN DRILLING INVITES COMPETITION.

The easier it is to drill a well in any given territory, the more wells will be drilled by small and inexperienced operators, and the greater will be the inefficient operation of the field. Furthermore, the indiscriminate drilling by inexperienced local operators always tends to increase the use of gas for manufacturing purposes, and takes the gas out at the fastest possible rate, thereby decreasing the effective life of the pool.

CRITICAL NEED OF THE NATURAL GAS INDUSTRY.

The natural gas industry is in a transition stage, going from the large volume and low-priced basis of the past to the small volume and inevitably higher price of the future. Strong individualism dominated the past. Public policy will ultimately require that legalized and regulated collective cooperation rather than cut throat competition, dominate the future. The greatest need of the industry

[1] For further discussion see United States National Museum Bulletin 102, Part 6, on Petroleum: A Resource Interpretation.

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to-day is the adequate recognition of the dominating factors in the natural gas conservation problem, which are:

1. Mandatory pooling of field operations, coupled with an adequate market price.

2. Education of the natural gas producers, and of the public, coupled with national constructive legislation. Any legislation, of course, to be of value to the public must be so framed as to stimulate production and the constant search for new supplies.

EFFECT OF GOVERNMENTAL OPPOSITION TO UNIFIED CONTROL.

The present governmental attitude in preventing unity of action in the gas field causes a decrease in the life of the leaseholds, stimulates waste, and increases the cost of the gas to the public. Gas field operating conditions should be regarded as a natural monopoly, so that in the development of the field one company, or one "operating pool," could space the wells properly, and drain the field only at the rate of its safe working capacity, thereby greatly increasing and strengthening the life of the field.

POOLING OF FIELD OPERATIONS MANDATORY IF WASTE IS TO BE REDUCED.

The economic fallacy of competition between untilities is now thoroughly established. Competition, either as a guarantor of good service or regulator of rates, has failed. The doctrine that the public is served best by a legalized and regulated monopoly has become a fixed part of American public utility jurisprudence, and ought to be applied to the mining operations in the natural gas field.

The maximum usefulness could be derived from a pool of oil or gas by its being controlled by one competent management, as under such conditions it could be developed with the least waste and at the smallest cost. However, rarely is a pool under one control; ordinarily a pool is divided among many owners. To get the best results the operators should act in unison for the protection of their common sources of supply and for their mutual benefit. To make cooperation among the producers in a field effective it seems necessary for them to organize with some central authority that can furnish protection against carelessness, inefficient, or even deliberately negligent acts of individuals. The center of this organization should be supplied with all the data affecting the common interests, which could be kept confidential if necessary, and from this information concerning conditions in the field general policies for development and operation could be outlined. That would work to the best interests of all concerned.

There is no business to-day in which, by its very nature, there is more need for cooperation than among the oil and gas operators, yet they have been able to do practically nothing by themselves. Nearly all attempts at cooperation among oil and gas producers have failed, primarily because there was no authority to compel the observance of the will of the majority by individuals who did not choose to follow the policies laid down.[1]

[1] Underground Wastes in Oil and Gas Fields and Methods of Prevention. Technical Paper 130, U. S. Bureau of Mines, pp. 4, 5, by W. F. McMurray and J. O. Lewis.

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PROVINCIAL THINKING CAUSE OF MOST NATURAL GAS WASTE.

The provincial habit of looking at natural gas from the dwarfed viewpoint of local use and immediate present is the primary cause of our acute natural gas service problems of to-day. The history of the industry has been one of unrestrained waste and profligate disregard for the public's interest, inevitably increasing demands and obvious physical limitations of supply. This wanton waste has been emphasized by creating and then emphasizing provincial aspects rather than recognizing the true national and interstate nature of the business. The selfish motive of trying to keep the natural resources of a State within the State boundaries, so as to make consumers locate within the State boundaries in order to enable them to use the resource, has been the dominating feature.

The following are three typical economic provincialisms that have been attempted. Although all of these have been unsuccessful, nevertheless they have stimulated the idea that natural gas was so cheap as not to be worth saving, and have therefore been provocative of much waste and misuse:

1. Attempting to prevent exporting gas beyond State *limits*.

2. Attempting to restrict the pressure which might be maintained in main lines, with the manifest object of preventing sufficient pressure to accomplish satisfactory interstate transmission.

3. Special tax upon the production and transmission of natural gas, and generally this has sought to discriminate in the tax as between gas consumption inside the State as against that transmitted for consumption outside the State.

The urgent present need is a clear appreciation and willing recognition that in the equitable administration of natural resources, *like* natural gas, there can be no State lines, and that a capital "The" belongs in front of United States in our national name. There is no more sense or justice in any other State either preventing or directly or indirectly burdening the exporting of natural gas, than there would be in applying the same provincial idea to the transportation of food. If it would be just for any State to say that you can not use "our" natural gas unless you locate within our State boundaries, it would be just as fair for the Minnesota farmer to say you can not eat my wheat unless you live within the State boundaries of Minnesota, or for the Louisiana sugar planter to say you can not use my sugar unless you come and live within the State boundaries of Louisiana. The last two viewpoints are so ridiculous that they would not receive serious consideration; yet they represent precisely what has been specifically attempted in the distribution of natural gas.

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CHARACTERISTICS OF NATURAL GAS PROSPECTORS AND NEW GAS SUPPLIES.

Natural gas prospectors are optimists, with individualism as the dominating characteristic. They are oversanguine, but if it were not for this characteristic they would not be searching for new supplies of gas. They do things in a big way, take large risks, are good sportsmen, and, therefore, good losers. However, the gains must in the end be more than the losses or they will not continue in the hunt for natural gas supplies for future service.

CONSERVATION OF NATURAL GAS POSSIBLE ONLY WITH PROFITABLE OPERATION.

Natural gas can be found only by diligent prospecting. After it is found the service can be maintained continuously only by further continued development and persistent searching for new supplies. In this development the prospector must figure on many dry holes. The average for all drilling in the entire United States is that every fourth hole is dry. In opening up new fields this may be much higher, brought out elsewhere.

Since the hazards are greater than in any other mining enterprise, the profits ought to be correspondingly greater. This element of profit is the only incentive which impels men to engage in so speculative an enterprise. If, in the aggregate, this amount of profit does not measure up to the hazards in the business the men will cease their work of prospecting and put their capital in safer enterprises. Wherever a close connection exists between effort and profit a stronger resulting incentive is furnished for a further and continuous expenditure of effort. Therefore, a high rate of profit, which will induce men to prospect continuously for natural gas, brings about the condition that more people can use gas and represents a distinct saving to the community.

Natural gas has never been equaled by any man-made product. The worth of natural gas for most high-grade utility services is ahead of any competing commodity or utility service. The only thing that will effectively conserve the supply for future use and thereby insure continuity of future service is an adequate price commensurate with the worth or value of the service. Therefore, the public is served best when natural gas mining is made profitable.

WHEN IS IT COMMERCIALLY FEASIBLE TO CONSERVE GAS OR DEVELOP NEW SUPPLIES?

The feasibility of conserving wastes or developing new supplies and connecting these with a market depends on the coordination of the following factors:

1. A study of the open-flow data in accordance with the doctrines laid down on page 20.

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2. Number of dry holes that have been drilled.

3. Probable rock pressure decline.

4. New drilling necessary to maintain production.

5. Total investment necessary in "conservation project" to save the gas.

6. Total investment in leases, wells, compressing stations, and transmission lines necessary to connect the gas with a market.

7. Operating cost of all the preceding factors.

8. In no case would it be prudent business or good judgment to attempt to conserve a waste of gas or develop a new supply that would not take care of the fixed charges on the investment and the operating cost during the life of the gas that is saved or developed on the basis of the volume of gas that can be obtained from such an enterprise and manufactured through the ultimate consumer's meter at the present market prices. An adequate price is therefore the crux of the natural gas conservation question. Unless it is made worth saving by the public it will not be good business judgment to attempt to save it.

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PUBLICATIONS OF THE DIVISION OF MINERAL TECHNOLOGY, UNITED STATES NATIONAL MUSEUM.

Publication 2421. Sources of nitrogen compounds in the United States, by Chester G. Gilbert. Issued June 30, 1916, Smithsonian Institution, 12 pp.

Bulletin 102, part 1. Coal products: An object lesson in resource administration, by Chester G. Gilbert. Issued Nov. 17, 1917. 16 pp., 11 pls.

Bulletin 102, part 2. Fertilizers: An interpretation of the situation in the United States, by Joseph E. Pogue. Issued Oct. 10, 1917. 22 pp., 1 pl.

Bulletin 102, part 3. Sulphur: An example of industrial independence, by Joseph E. Pogue. Issued Nov. 7, 1917. 10 pp., 1 fig., 3 pls.

Bulletin 102, part 4. Coal: The resource and its full utilization, by Chester G. Gilbert and Joseph E. Pogue. Issued Feb. 21, 1918. 26 pp.

Bulletin 102, part 5. Power: Its significance and needs, by Chester G. Gilbert and Joseph E. Pogue. Issued Sept. 21, 1918. 50. pp., 2 figs.

Bulletin 102, part 6. Petroleum: A resource interpretation, by Chester G. Gilbert and Joseph E. Pogue. Issued Aug. 1, 1918. 76 pp., 12 figs., 3 pls.

Bulletin 102, part 7. Natural gas: Its production, service, and conservation, by Samuel S. Wyer. Issued ———, 1918.

Bulletin 102, vol. 1. The energy resources of the United States: A plan for reconstruction, by Chester G. Gilbert and Joseph E. Pogue. (In press.)

NOTE.—The papers listed above as parts of Bulletin 102 are members of a series entitled "The mineral industries of the United States."

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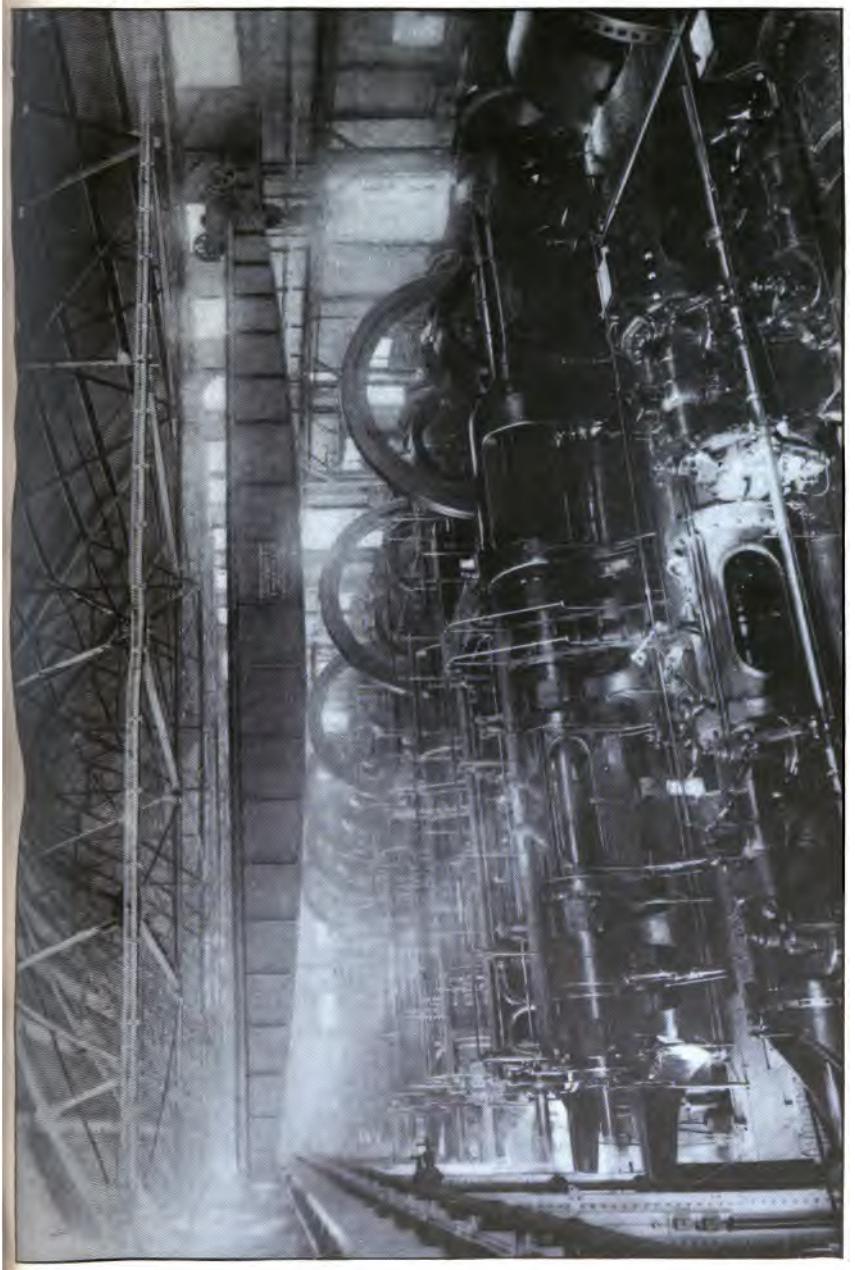

INTERIOR OF NATURAL GAS COMPRESSING STATION.

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NATURAL GAS MAIN LINE CONSTRUCTION CONDITIONS.

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NATURAL GAS MAIN LINE RIVER CROSSING UNDER CONSTRUCTION.

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WASTE OF NATURAL GAS IN BLOWING SALT WATER FROM WELL.

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THE EFFECT OF ELECTROLYSIS ON GAS PIPE.

Gas pipe from Kansas City, Mo., showing holes produced by electrolysis, and therefore many opportunities for waste of gas through leakage. This also produces serious life and property hazard. The term "electrolysis" as here used means the destructive, disintegrating, chemical action, and the resulting damage of underground metallic structures when stray electric currents from electric railways have leaked from their own return circuit and wandered to other underground structures and thence back into the soil.

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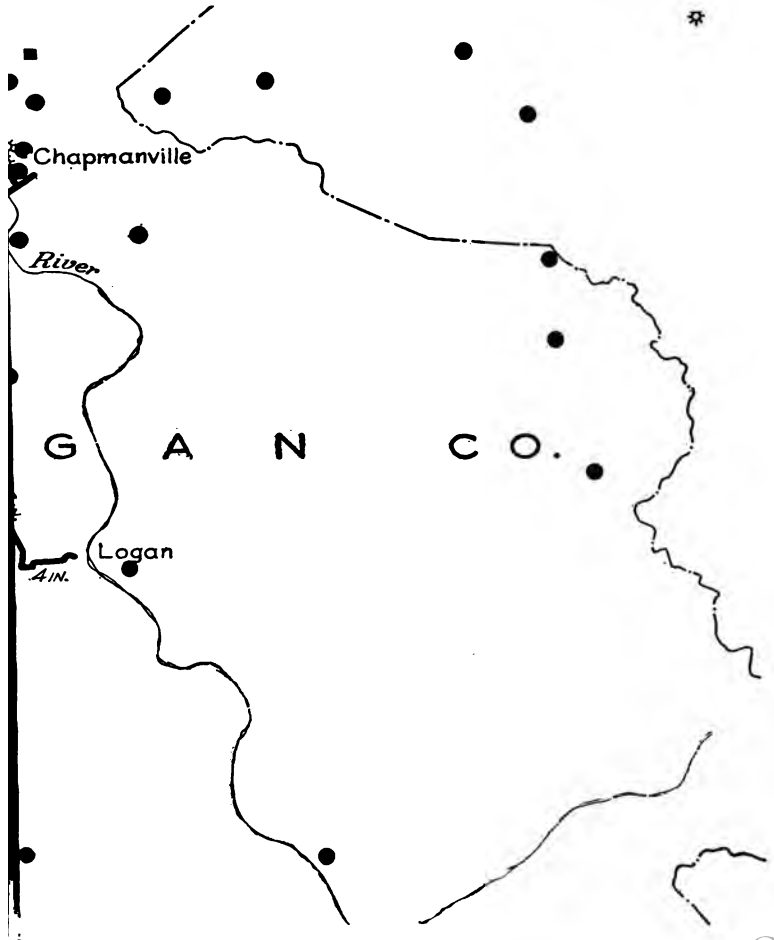

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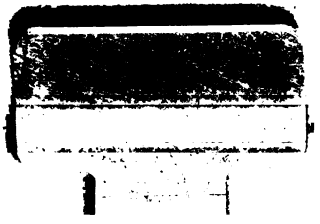

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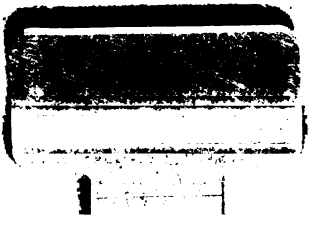

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